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(54) Title: TENASCIN-W COMPOSITIONS AND USES THEREOF

(57) Abstract: Tenascin-W, an extracellular matrix molecule that is specifically expressed in metastatic tumours is provided. A system comprising a sample expressing tenascin-W is used as an *in vitro* method for screening possible anti-tumour agents or for agents that promote osteogenesis.

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TENASCIN-W COMPOSITIONS AND USES THEREOF

5     The present invention relates to polypeptides specifically expressed in tumours, to active agents having anti-tumour and/or anti-tumourigenic activity and to agents effective in improving conditions dependent on stem cell differentiation, in particular osteoblast formation, such as in osteogenesis, to pharmaceutical compositions of these agents and to the pharmaceutical uses  
10    of such agents and compositions. The invention also relates to *in vitro* methods of screening agents for anti-tumour and/or anti-tumourigenic activity as well as for agents effective in promoting stem cell differentiation.

15    The adherence of cells to each other and to the extracellular matrix (ECM) as well as the cellular signals transduced as a consequence of such binding are of fundamental importance to the development and maintenance of body form and function. The ECM has an important regulatory function in tissue homeostasis and, together with oncogenes and tumour suppressor genes is involved in tumourgenesis (reviewed in Boudreau, N. & Bissell, M. J.  
20    (1998) Curr Opin Cell Biol 10: 640-646 and Ruoslahti, E. (1999) Adv Cancer Res 76: 1-20).

25    In the more affluent countries of the world cancer is the cause of death of roughly one person in five with the five most common cancers being those of the lung, stomach, breast, colon/rectum and the uterine cervix. Tumors of this type often metastasize through lymphatic and vascular channels. Cancer is not fatal in every case and only about half the number of people who develop cancer die of it. The problem facing cancer patients and their physicians is that seeking to cure cancer is like trying to get rid of weeds.

30

One way to treat cancer effectively is to get an early diagnosis. Most cancers are not extensively vascularized (and therefore not invasive) during the early stages of development. The transition to a highly vascularized, invasive and ultimately metastatic cancer which spreads throughout the body commonly

takes ten years or longer. If the cancer is detected prior to invasion, surgical removal of the cancerous tissue is an effective cure. However, cancer is often detected only upon manifestation of clinical symptoms. Generally, such symptoms are present only when the disease is well established, often after metastasis has occurred, and the prognosis for the patient is poor, even after surgical resection of the cancerous tissue. Early detection of cancer therefore is important in that detection may significantly reduce morbidity. A reliable, non-invasive, and accurate technique for diagnosing cancer at an early stage would help save many lives.

10

Cancer cells can be removed surgically or destroyed with toxic compounds or with radiation but it is very hard to eliminate all of the cancerous cells. A general goal is therefore to find better ways of selectively killing cancer cells whilst leaving normal cells of the body unaffected. Part of that effort involves identifying new anti-cancer agents.

15

Apart from tumorigenesis, the ECM has an important regulatory function in tissue homeostasis and in the development and maintenance of body form and function, e.g. in the development or remodeling of skeleton or in bone morphogenesis. Bone marrow has stem cells with osteogenic potential and is made up of determined osteogenic precursor cells that are committed to osteogenesis and of inducible osteogenic precursor cells. Determined osteogenic precursor cells can differentiate into bone without an exogenous signal. Inducible osteogenic precursor cells require a molecular signal for initiating the differentiation program, e.g. induction by binding to extracellular matrix.

20

A number of molecules mediating cell adhesion have been identified and characterized at the molecular level both in vertebrates and invertebrates.

25

Tenascins are a family of large multimeric extracellular matrix proteins, each having homologous subunits built from variable numbers of repeated domains. These include heptad repeats, epidermal growth factor (EGF)-like repeats, fibronectin type III domains and a C-terminal globular domain which is also found in fibrinogens. Tenascin-C was the first member of the family to

be discovered, in one instance as a myotendinous antigen (Chiquet, M. & Fambrough, DM. (1984) *J Cell Biol* 98(6):1937-1946) and in another, as a protein enriched in the stroma of gliomas (Bourdon, MA. et al (1983) *Cancer Res* 43(6):2796-2805, reflecting the major sites of tenascin-C expression, 5 namely in tendons and ligaments and the extracellular matrix of tumor stroma. A further instance of the discovery of tenascin-C (also termed hexabrachion) reflects its interaction with fibronectin (Erickson, HP. et al. (1984) *Nature* 311(5983):267-9). Enforced interaction of tumour cells with fibronectin can block proliferation in cell culture and can decrease tumour growth in nude 10 mice (Akamatsu H. et al (1996) *Cancer Res* 56: 4541-4546 and Giancotti, F. G & Ruoslahti, E. (1990) *Cell* 60: 849-859). Tenascin-C was shown to disrupt the interaction of cells with fibronectin and in this manner may enhance 15 tumour cell proliferation. Chiquet-Ehrismann, R. et al (1988) *Cell* 53: 383-390 were the first to show that tenascin-C binds to fibronectin, blocks cell attachment to fibronectin and increases proliferation of rat breast adenocarcinoma cells (Chiquet-Ehrismann, R. et al / *Mol Biol Cell* 7: 131-139).

Tenascin-C is present in a large number of developing tissues including the nervous system. Although abundant in mature ligaments and tendons, it is 20 absent from skeletal and heart muscle, unless the muscle has been injured. Tenascin-C expression is elevated in essentially all carcinomas as well as in many other types of tumors (for review see Chiquet-Ehrismann, R. (1993) *Semin Cancer Biol* 4(5):301-10). Furthermore, tenascin-C is upregulated in wound healing (Latijnhouwers, MA. et al. (1996) *J Pathol* 178(1):30-5), during 25 skeletogenesis (Koyama, E. et al (1996) *J Orthop Res.* 14(3):403-412 and Hall, BK. & Miyake, T. (1995) *Int J Dev Biol.* 39(6):881-893) as well as in many diseases involving infections and inflammation (Schenk, S. et al. (1995) *Int J Cancer* 61(4):443-9).

30 Each tenascin family member exhibits a specific gene expression pattern during embryogenesis and in the adult (for review see Chiquet-Ehrismann, R. (1995) *Experientia* 51(9-10):853-62) suggesting specific roles for each member. Tenascin-R is an extracellular matrix component of the nervous system found mainly in brain tissue (Pasheva, P. et al. (2001) *Prog Brain Res.*

132:103-14. Review), whereas tenascin-X is prominently expressed in muscle and skin connective tissue. In one patient, tenascin-X deficiency has been reported to result in an Ehler's Danlos phenotype (Burch, GH. et al. (1997) Nat Genet 17(1):104-8).

5

To date there is only one report on tenascin-W available in the literature.

(Weber, P. et al. (1998) J Neurobiol 35(1):1-16). In this study, a cDNA encoding tenascin-W was isolated from a 20-28h postfertilization zebrafish cDNA library on the basis of the conserved epidermal growth factor-like

10 domains found in all tenascin molecules. The expression pattern of tenascin-W transcripts was studied in the developing zebrafish by *in situ* hybridisation. It was found to be present in neural crest and sclerotome cells and the developing skeleton. Genebank sequence AJ001423 provides a zebrafish tenascin-W, and AL049689 provides a "novel human mRNA from 15 chromosome 1, similar to Tenascin-R", whose function is not known.

The present invention provides a composition comprising an isolated nucleic acid molecule having a nucleotide sequence selected from the group consisting of:

20 (a) a nucleotide sequence as set forth in SEQ ID NO: 1;  
(b) a nucleotide sequence encoding the amino acid sequence shown in SEQ ID NO: 2;  
(c) a nucleotide sequence with at least 85% identity to the sequence of (a) or (b);  
25 (d) a subsequence of more than 50 consecutive nucleotides of a sequence of (a), (b) or (c); and  
(e) a nucleotide sequence complementary to any of the nucleotide sequences or subsequence in (a),(b), (c) or (d).  
  
30 In one aspect of the invention, the isolated nucleic acid molecule having a nucleotide sequence preferably exhibits at least 85% identity to the sequence of (a), more preferably encoding a variant of the amino acid sequence shown in SEQ ID NO: 2, such as a variant comprising an amino acid deletion, addition (e.g. fusion proteins) or substitution of the amino acid sequence

shown in SEQ ID NO:2. Preferably, the variant comprises a conservative substitution of at least one amino acid in said amino acid sequence in SEQ ID: NO: 2, more preferably the variant has stem cell differentiation inducing activity, in particular an activity that induces osteoblast development from 5 stem cells. Most preferred is when the isolated nucleic acid molecule encodes a protein with the amino acid sequence shown in SEQ ID NO: 2.

The nucleic acid molecule can be an antisense molecule, in which case it might be desirable to have nucleotide residues that are resistant to nuclease 10 degradation substituting some or all of the ribo- or deoxyribonucleotides.

Also provided are nucleic acid vectors comprising the nucleic acid molecules of the invention, as well as host cells comprising the vectors or nucleic acids, and transgenic, knockout or genetically modified animals (other than humans, 15 in particular mice), comprising manipulated nucleic acids of the invention or absent of anogenous sequence.

The invention also provides a composition comprising an isolated polypeptide having an amino acid sequence selected from the group consisting of:

- 20 (a) an amino acid sequence as set forth in SEQ ID No. 2; and
  - (b) an amino acid sequence with at least 85% identity to the sequence of (a); and
    - (c) a subsequence of at least 30 consecutive amino acids of the sequence of (a) or (b), with the proviso that said subsequence does not fall within amino acid nos. 1102 and 1152 of SEQ ID NO:2.

Preferably, the amino acid sequence in (b) comprises a conservative substitution of at least one amino acid of the amino acid sequence of SEQ ID: NO: 2. More preferably, the polypeptide or fragment has stem cell 30 differentiation inducing activity, as described above. Useful fragments may exhibit an epitope recognized by polyclonal antibodies raised against the polypeptide having the amino acid sequence shown in SEQ ID NO: 2, for example. A particularly preferred polypeptide is that encoded by the amino acid sequence shown in SEQ ID NO: 2.

Also provided are antibodies that are specifically reactive against the polypeptides of the invention.

- 5 In another aspect of the invention, a composition comprising an isolated nucleic acid molecule having a nucleotide sequence selected from the group consisting of:
  - (a) a nucleotide sequence as set forth in SEQ ID No. 1 or SEQ ID No. 3;
  - (b) a nucleotide sequence encoding the amino acid sequence shown in SEQ ID NO: 2 or SEQ ID NO: 4;
  - 10 (c) a nucleotide sequence with at least 35% identity to any one of the sequences of (a) or (b), preferably (a);
  - (d) a subsequence of at least 15 consecutive nucleotides of the sequence of (a),(b) or (c); and.
  - 15 (e) a nucleotide sequence complementary to (a),(b), (c), or (d), and a pharmaceutically acceptable excipient, diluent or carrier.

In one embodiment, the nucleic acid molecule preferably encodes a protein having stem cell differentiation inducing activity. In another embodiment, the nucleic acid molecule has a subsequence that is antisense to SEQ ID NO:1 or SEQ ID NO:3, wherein the nucleic acid molecule may comprise nucleotide residues that are resistant to nuclease degradation. In another embodiment, the isolated nucleic acid molecule encodes the amino acid sequence shown in SEQ ID NO: 2 or SEQ ID NO:4. In yet another embodiment, the nucleic acid molecule has a subsequence selected from the group consisting of nucleotides 2380-3171 of SEQ ID No:1, nucleotides 2371-3162 of SEQ ID No:3, a complement of nucleotides 2380-3171 of SEQ ID No:1, and a complement of nucleotides 2371-3162 of SEQ ID No:3, or an RNA equivalent thereof.

30 Thus, also provided are nucleic acid compositions as described above for use as a pharmaceutical, as well as the use of such compositions for the manufacture of a medicament for the prophylaxis or treatment of cancer or bone pathologies.

Also provided are compositions comprising tenascin-W, preferably recombinant tenascin-W, and a pharmaceutically acceptable excipient, diluent or carrier. In preferred embodiments, the tenascin-W is a polypeptide having

5 an amino acid sequence selected from the group consisting of:

- (a) an amino acid sequence as set forth in SEQ ID No. 2 or 4;
- (b) an amino acid sequence with at least 35% identity to the sequence of (a); and
- (c) a subsequence of at least 30 consecutive amino acids of the sequence of (a) or (b).

10 Preferably, the polypeptide has stem cell differentiation inducing activity as described above. More preferably, the polypeptide is encoded by the amino acid sequence shown in SEQ ID NO: 4.

15 Thus, also provided is the use of tenascin-W for the treatment or prophylactic treatment of any disease or condition requiring increased tenascin-W levels, e.g. thrombosis, wound healing or atherosclerosis, as well as a condition ameliorated by the promotion of osteogenesis, e.g. bone healing,

20 osteoporosis, as well as the use of tenascin-W as a stem cell marker.

Also provided are antibodies that specifically recognizes tenascin W for use as a pharmaceutical, as well as for the manufacture of a medicament, for the prophylaxis or treatment of cancer (e.g., glioblastoma, prostate, lung, 25 colorectal, osteo- or breast carcinoma), including metastatic cancer, or for the prophylaxis or treatment of any disease or condition involving tenascin-W, e.g. excessive bone growth.

The present invention also provides methods for identifying agents for the 30 prevention or the prophylactic treatment of tumourigenesis or the treatment or prophylactic treatment of tumours or cancer, or the treatment or prophylactic treatment of any disease or condition involving tenascin-W, e.g. a condition ameliorated by the promotion or inhibition of osteogenesis, comprising

contacting a test compound with a tenascin-W expressing cell sample and then measuring a change in one or more of:

- (a) cell proliferation, e.g. cell progression entering S-phase of the cell cycle;
- 5 (b) DNA synthesis;
- (c) cell adhesion;
- (d) cell spreading;
- (e) focal adhesion and actin stress fibre formation on fibronectin; and
- (f) cell binding to extracellular matrix (ECM)

10 relative to when said test compound is absent.

Optionally, the method further comprises measuring a change in tenascin-W expression relative to when the test compound is absent. The tenascin-W may have any one or more of the features described above. A particularly

15 preferred assays is carried out in the form of an enzyme linked immunosorbent assay (ELISA).

Also provided is a method for identifying regulators of tenascin W function, comprising:

20 (a) contacting a test compound with tenascin W and/or alpha8 beta1 integrin, and  
(b) measuring the binding of the test compound to tenascin-W and/or alpha8 beta1 integrin, or  
(c) measuring a disruption of binding of tenascin-W to alpha8 beta1 integrin,  
25 relative to when the test compound is absent.

Optionally the method further comprises measuring the binding of a control compound to tenascin-W. In one embodiment, the tenascin-W is attached to a solid surface, for example using an antibody reactive against tenascin-W. The binding can be conveniently detected using an antibody labelled with a fluorescent label, a fluorescence quencher, a radioactive label, a scintillant or an enzyme. Alternatively, the binding is detected by measuring the adhesion of alpha8 beta1 to the immobilized tenascin-W (as described in example 8) or

vice versa. A decrease in binding of tenascin-W to alpha8 beta1 integrin is indicative of an inhibitor of the tenascin-W to alpha8 beta1 integrin interaction (and therefore an inhibitor of tenascin W function). An increase in binding of tenascin-W to alpha8 beta1 integrin in the presence of a test compound is 5 indicative of a potential agent that activates alpha8 beta1 integrin, thereby acting as an agonist of tenascin-W function.

Thus also provided, are agents for the prevention or the prophylactic treatment of tumourigenesis or the diagnosis or the treatment or prophylactic 10 treatment of tumours, or the treatment or prophylactic treatment of any disease or condition involving tenascin-W, e.g. a condition ameliorated by the promotion of osteogenesis, identified by a screening method of the invention.

Also provided are methods of diagnosing or prognosing cancer comprising:

15 (a) analysing a sample obtained from an individual for the presence of tenascin-W and  
(b) correlating the presence of tenascin-W with an unfavourable prognosis or diagnosis.

20 Optionally, the method may further comprise correlating in an increase in (elevated level of) tenascin-W in the sample relative to healthy tissue with an unfavourable prognosis or diagnosis. Tenascin-W can be conveniently detected using an antibody specific for tenascin-W or alternatively tenascin-w can be detected at the transcript level using techniques well known in the art, such as a polymerase chain reaction (e.g., RT-PCR). The method may also 25 include the additional use of controls.

The sample can be blood serum from an individual, for example. The method may also further comprise propagating cells in a sample in cell culture. In one 30 embodiment, the method further comprises analysing the sample for the presence of alpha 8 integrin, the presence of alpha 8 integrin correlating with an unfavourable prognosis or diagnosis.

The present inventors have investigated extracellular matrix molecules, their  
5 expression during development, cell adhesion and proliferation of tumour cells  
and have characterized a novel member of the mammalian tenascin family.  
Prior to the present invention, no tenascin-W had been identified from a  
mammalian source and its function was not previously known. The present  
inventors have identified and characterized the complete cDNA sequence  
10 encoding the mouse and human tenascin-W. Antisera were prepared against  
a fragment of tenascin-W, which detect tenascin W in tumour stroma, in the  
periosteum and in liver tissue, and cross react with tenascin W from several  
mammalian species. In particular, the inventors have discovered that  
tenascin-W is specifically expressed in metastatic tumour cells as well as in  
15 the periosteum, the stem cell compartment for osteogenesis.

Thus, in one aspect, the present invention provides a composition comprising  
an isolated nucleic acid molecule having a nucleotide sequence selected from  
the group consisting of:

- 20 (a) a nucleotide sequence as set forth in SEQ ID NO: 1;
- (b) a nucleotide sequence encoding the amino acid sequence  
shown in SEQ ID NO: 2;
- (c) a nucleotide sequence with at least 85% identity to the sequence  
of (a) or (b);
- 25 (d) a subsequence of more than 50, 75, 100, 200 or more  
consecutive nucleotides of a sequence of (a), (b) or (c); and
- (e) a nucleotide sequence complementary to any of the nucleotide  
sequences or subsequence in (a),(b), (c) or (d).

30 The compositions include various types of nucleic acid, including genomic DNA, cDNA and mRNA, for example. In one aspect of the invention, the isolated nucleic acid molecule having a nucleotide sequence preferably exhibits at least 85% identity, more preferably 90% identity, most preferably 95, 98 or 100% identity to the sequence of (a) (SEQ ID NO:1). Also

encompassed are nucleic acids that encode polypeptides having the amino acid sequence shown in SEQ ID NO: 2, or variants thereof such as a variant comprising an amino acid deletion, addition (e.g. fusion proteins) or substitution relative to the amino acid sequence shown in SEQ ID NO:2. The various nucleic acids that can encode these polypeptides therefore may differ because of the degeneracy of the genetic code, in that most amino acids are encoded by more than one triplet codon. The identity of such codons is well known in this art, and this information can be used for the construction of the nucleic acids within the scope of the invention. Variants differ from wild-type protein in having one or more amino acid substitutions that either enhance, add, or diminish a biological activity of the wild-type protein. Once the amino acid change is selected, a nucleic acid encoding that variant is constructed according to methods well known in the art.

15 Preferably, the variant comprises a conservative substitution of at least one amino acid in said amino acid sequence in SEQ ID: NO: 2. The variants typically exhibit a biological function of the polypeptide as set forth in SEQ ID NO:2, that is, stem cell differentiation inducing activity; in particular, activity that induces osteoblast development from stem cells, or binding to an antibody that specifically recognizes Tenascin-W. To maintain biological activity, only conservative substitutions are therefore preferred as is well known in the art. Most preferred is when the isolated nucleic acid molecule encodes a protein with the amino acid sequence shown in SEQ ID NO: 2.

25 The nucleic acid molecule can be an antisense molecule, in which case it might be desirable to have nucleotide residues that are resistant to nuclease degradation substituting some or all of the ribo- or deoxyribonucleotides. Such nucleotide residues resistant to nucleases are well known in the art and can be easily synthesized by chemical means.

30 Also provided are nucleic acid vectors comprising the nucleic acid molecules of the invention, as well as host cells comprising the vectors or nucleic acids, and transgenic, knockout or genetically modified animals (other than humans,

in particular mice), comprising manipulated nucleic acids of the invention or absent the endogenous sequence.

The invention also provides a composition comprising an isolated polypeptide

5 having an amino acid sequence selected from the group consisting of:

- (a) an amino acid sequence as set forth in SEQ ID NO: 2;
- (b) an amino acid sequence with at least 85% identity, preferably 90, 95, 98 or 100% identity to the sequence of (a); and
- (c) a subsequence of at least 30, 40, 50, 75, 100 or more consecutive amino acids of the sequence of (a) or (b), with the proviso that said 10 subsequence does not fall within amino acid nos. 1102 and 1152 of SEQ ID NO:2.

Preferably, the amino acid sequence in (b) comprises a conservative

15 substitution of at least one amino acid of the amino acid sequence of SEQ ID:

NO: 2. More preferably, the polypeptide having stem cell differentiation inducing activity, as described above. Useful fragments may exhibit an epitope recognized by polyclonal antibodies raised against the polypeptide having the amino acid sequence shown in SEQ ID NO: 2, for 20 example. A particularly preferred polypeptide is that encoded by the amino acid sequence shown in SEQ ID NO: 2, derived from mouse tissue.

Therefore, also included within the invention are variants and derivatives of the polypeptide described by SEQ ID NO:2 or fragment thereof, whether

25 produced by recombinant means or synthetic means or isolated from naturally occurring sources. For example, peptides having modified amino acids/peptide linkages, and peptides containing non-naturally occurring amino acids and/or cyclic peptides, which may have improved properties such as stability or activity are included. In addition the peptides of the invention may 30 be in the form or a fusion with another protein, for example, tags for the targeted delivery or detection, or purification of the polypeptide (including fragments thereof).

A "variant" in terms of amino acid sequence defines an amino acid sequence that differs by one or more amino acids from another, usually related amino acid sequence. The variant may have "conservative" changes, wherein a substituted amino acid has similar structural or chemical properties (e.g.

5 replacement of leucine with isoleucine). Less likely, a variant may have "non-conservative" changes, e.g. replacement of a glycine with a tryptophan.

Similar minor variations may also include amino acid deletions or insertions (i.e. additions), or both. Guidance in determining which and how many amino acid residues may be substituted, inserted or deleted without abolishing

10 activity (e.g., anti-cancer activity, osteoblast promoting activity, antigenic activity) may be found using computer programs well known in the art.

Variants of the polypeptides of the invention include all forms of mutant variants, for example wherein at least one amino acid is deleted or substituted. Any changes involving substitution of amino acids are preferably

15 neutral or conservative substitutions. Other variants include proteins or polypeptides containing at least one additional amino acid in the sequence, and/or further comprising an additional amino acid sequence or domain, such as fusion proteins well known in the art.

20 Further variants of the polypeptides of the invention include those wherein at least one of the amino acids in the sequence is a natural or unnatural analogue. Also, one or more amino acids in the sequence may be chemically modified, e.g. to increase physical stability or to lower susceptibility to enzymic, particularly protease or kinase, activity.

25 Also provided are antibodies that are specifically reactive against the polypeptides of the invention. Methods for producing antibodies are well known in the art. An antibody specific for the polypeptide of the invention can be easily obtained by immunizing an animal with an immunogenic amount of  
30 the polypeptide. Therefore, an antibody recognizing the polypeptide of the invention embraces polyclonal antibodies and antiserum which are obtained by immunizing an animal, and which can be confirmed to specifically recognize the polypeptide of the invention by Western blotting, ELISA, immunostaining or other routine procedure known in the art.

It is well known that if a polyclonal antibody can be obtained by sensitization, a monoclonal antibody secreted by a hybridoma may be obtained from the lymphocytes of the sensitized animal (Chapter 6, Antibodies A Laboratory Manual, Cold Spring Harbor Laboratory Press, 1988). Therefore, monoclonal antibodies recognizing the polypeptide of the invention are also provided. Methods of producing polyclonal and monoclonal antibodies are known to those of skill in the art and described in the scientific and patent literature, see, e.g., Coligan, Current Protocols in Immunology, Wiley/Green, NY (1991); Stites (eds.) Basic and Clinical Immunology (7th ed.) Lange Medical Publications, Los Altos, CA, and references cited therein (Stites); Goding, Monoclonal Antibodies: Principles and Practice (2nd ed.) Academic Press, New York, NY (1986); and Kohler (1975) *Nature* 256: 495. Such techniques include selection of antibodies from libraries of recombinant antibodies displayed in phage or similar on cells. See, Huse (1989) *Science* 246: 1275 and Ward (1989) *Nature* 341: 544. Recombinant antibodies can be expressed by transient or stable expression vectors in mammalian cells, as in Norderhaug (1997) *J. Immunol. Methods* 204: 77-87.

In this invention, an antibody also embraces an active fragment thereof. An active fragment means a fragment of an antibody having activity of antigen-antibody reaction. Specifically named, these are active fragments, such as F(ab')<sub>2</sub>, Fab', Fab, and Fv. For example, F(ab')<sub>2</sub> results if the antibody of this invention is digested with pepsin, and Fab results if digested with papain. Fab' results if F(ab')<sub>2</sub> is reduced with a reagent such as 2-mercaptoethanol and alkylated with monoiodoacetic acid. Fv is a mono active fragment where the variable region of heavy chain and the variable region of light chain are connected with a linker. A chimeric antibody is obtained by conserving these active fragments and substituting the fragments of another animal for the fragments other than these active fragments. In particular, humanized antibodies are envisioned.

The nucleic acid and polypeptide sequences investigated herein have been found to be differentially expressed in samples obtained from metastatic

cancer cell lines and are predictive of tenascin-W expression in metastatic cancer tissue, as well as in other types of cancer and diseases.

Accordingly, certain aspects of the present invention relate to nucleic acids  
5 differentially expressed in tumour tissue, especially metastatic cancer cell  
lines, polypeptides encoded by such nucleic acids, and antibodies  
immunoreactive with these polypeptides, and preparations of such  
compositions. Moreover, the present invention provides diagnostic and  
therapeutic assays and reagents for detecting and treating disorders involving,  
10 for example, aberrant expression of the subject nucleic acids.

Thus, in a further aspect of the invention, a composition is provided comprising an isolated nucleic acid molecule encoding tenascin W or a fragment thereof and a pharmaceutically acceptable excipient, diluent or  
15 carrier. The pharmaceutical use of nucleic acids encoding tenascin W has not previously been suggested and therefore in this embodiment, the nucleic acids of the pharmaceutical compositions are not limited to the nucleic acids of the invention. In particular, the composition may comprise an isolated nucleic acid having a nucleotide sequence selected from the group consisting  
20 of:  
  
(a) a nucleotide sequence as set forth in SEQ ID No. 1 or SEQ ID No. 3 (encoding human tenascin.W);  
(b) a nucleotide sequence encoding the amino acid sequence shown in SEQ ID NO: 2 or SEQ ID NO: 4;  
25 (c) a nucleotide sequence with at least 35% identity, preferably at least 40, 50, 60, 70, 80, 90, 95 or 100% identity to any one of the sequences of (a) or (b), preferably (a);  
(d) a subsequence of at least 10, 15, 20, 25, 30, 40, 50, 75, 100 or more consecutive nucleotides of the sequence of (a),(b) or (c); and  
30 (e) a nucleotide sequence complementary to (a),(b), (c), or (d), and a pharmaceutically acceptable excipient, diluent or carrier.

In one embodiment, the nucleic acid molecule encodes tenascin-W having the amino acid sequence as set forth in SEQ ID No. 2 or SEQ ID NO. 4 or an

amino acid with at least 30%, preferably at least 50%, 70%, 80%, 90%, 95%, or 100% identity to a sequence corresponding to SEQ ID NO:2 or 4. The nucleic acid molecules are at least 10, preferably at least 15, 20, 30, 50, 75, 100 or more consecutive nucleotides of SEQ ID No. 1 or SEQ ID No.2 or a sequence complementary thereto.

5 In one embodiment, the invention provides a composition comprising a nucleotide sequence fragment selected from the group consisting of nucleotides 2380-3171 of SEQ ID No:1 or nucleotides 2371-3162 of SEQ ID 10 No:3, a complement of nucleotides 2380-3171 of SEQ ID No:1 or of nucleotides 2371-3162 of SEQ ID No:3, and RNA equivalents thereof, which encode an epitope for the binding with an antibody paratope.

15 In another embodiment, the nucleic acid molecule preferably encodes a protein having stem cell differentiation inducing activity. Although it is well within the skill of the art to identify polypeptides having the appropriate activity using routine methodology, the isolated nucleic acid molecule preferably encodes the amino acid sequence shown in SEQ ID NO: 2 or SEQ ID NO:4, most preferably that of SEQ ID NO:4.

20 In yet another embodiment, the nucleic acid molecule has a subsequence that is antisense to SEQ ID NO:1 or SEQ ID NO:3, wherein the nucleic acid molecule may comprise nucleotide residues that are resistant to nuclease degradation.

25 The nucleic acid may be antisense to all or a part of a nucleic acid which hybridizes under stringent conditions to SEQ ID No:1 or SEQ ID No:3, or antisense to a sequence having at least 70% identity with SEQ ID NO:1 or SEQ ID NO:3, that is able to hybridize under low stringency conditions to SEQ 30 ID NO:1 or SEQ ID NO:3, and which encodes tenascin-W. Low stringency conditions employs around 0.01 x SSC buffer compared to high stringency which employs about a 10 fold greater concentration. Alternatively, the antisense RNA may be antisense to regulatory sequences of the tenascin-W gene, in particular to 5' upstream sequences (promoter region) of the gene.

Similarly, small RNAi oligonucleoties can be designed to inhibit expression of Tenascin-W in a specific manner.

The nucleic acids can be RNA or DNA, sense or antisense, and in some

5 embodiments, double stranded (including siRNA) or single stranded. In certain embodiments at least some of the nucleotide residues of the nucleic acids (sense or antisense) may be made resistant to nuclease degradation and these can be selected from residues such as phosphorothioates and/or methylphosphonates.

10

The antisense nucleic acids as hereinbefore described can advantageously be used as pharmaceuticals, preferred pharmaceutical applications being for the manufacture of a medicament for the prophylaxis or treatment of conditions dependent on elevated Tenascin W levels, such as cancer.

15

Thus, the invention provides a method of preventing or treating a condition dependent on Tenascin W, comprising administering to an individual an effective amount of a nucleic acid, as hereinbefore described. Thus, the invention encompasses the use of such nucleic acid molecules as a

20 pharmaceutical, as well as for the manufacture of a medicament, in particular for the prophylaxis or treatment of cancer or bone pathologies.

In yet another aspect, the present invention provides expression vectors capable of replicating in a host cell, comprising one or more vector sequences 25 and a nucleic acid sequence encoding teneurin-W. The construct for use as a pharmaceutical is also provided, as well as its use for the manufacture of a medicament for the prophylaxis or treatment of cancer or the prophylaxis or treatment of bone pathologies.

30 Other embodiments of the invention include nucleic acid constructs capable of replicating in a host cell, comprising (a) at least one nucleic acid sequence portion encoding a tenascin-W protein or polypeptide of the invention (b) antisense nucleic acids as hereinbefore described (or their complement, for example, if expression of the antisense RNA in a cell is foreseen), or (c)

nucleic acids as hereinbefore described and at least one nucleic acid sequence encoding a protein other than tenascin-W (or its homologues), e.g. vector sequence. Such constructs are not naturally occurring sequences. The constructs lack essential sequences of DNA which might permit them to 5 function as vectors but are not naturally occurring as "hybrid" nucleic acids. They may include nucleic acid sequences that function as linkers or restriction sites which include without limitation a transcriptional regulatory sequence operably linked to a nucleotide sequence of the invention so as to render said nucleic acid construct capable of replicating in a host cell. Preferred 10 constructs are synthesised using methods of oligonucleotides synthesis well known to those of skill in the art.

Also provided are vectors comprising a construct as hereinbefore described. Preferred vectors are expression vectors, preferably plasmids or viruses 15 although cloning vectors are also provided for, optionally in the form of plasmids.

The invention provides host cells containing vectors. Preferred host cells are eukaryotic cells, more preferably insect cells or mammalian cells. 20 Constructs, vectors and transformed host cells of the invention are of use as pharmaceuticals, as well as for the manufacture of a medicament for the prophylaxis or treatment of a condition dependent on tenascin W, such as cancer or bone disorders.

Similarly, in a further aspect of the invention, a composition is provided 25 comprising tenascin W, preferably recombinant tenascin-W, or a fragment thereof and a pharmaceutically acceptable excipient, diluent or carrier. In preferred embodiments, the tenascin-W is a polypeptide having an amino acid 30 sequence selected from the group consisting of:  
(a) an amino acid sequence as set forth in SEQ ID No. 2 or 4;  
(b) an amino acid sequence with at least 35% identity, preferably at least 50%, 70%, 80%, 90%, 95%, or 99% identity to the sequence of (a); and

(c) a subsequence of at least 5, 10, 15, 20, 30, 50, 75, 100 or more consecutive amino acids of the sequence of (a) or (b).

Preferably, the polypeptide has stem cell differentiation inducing activity as  
5 described above. More preferably, the polypeptide is encoded by the amino acid sequence shown in SEQ ID NO: 4.

Thus, also provided is the use of tenascin-W for the treatment or prophylactic treatment of any disease or condition requiring increased tenascin-W levels,  
10 e.g. thrombosis, wound healing or atherosclerosis, as well as a condition ameliorated by the promotion of osteogenesis, e.g. bone healing, osteoporosis, as well as the use of tenascin-W as a stem cell marker.  
In yet a further aspect, the tenascin-W protein is used as a pharmaceutical.

15 The present invention further provides the use of a tenascin-W, e.g. for the manufacture of a medicament, for the prevention or prophylactic treatment of tumourigenesis or the treatment or prophylactic treatment of tumours or cancer. The invention also includes the use of the tenascin-W for the manufacture of a medicament for the treatment or prophylactic treatment of  
20 any one or more of bone disease, rheumatism, asthma, allergic diseases, autoimmune diseases, prevention of transplant rejection and any other diseases involving tenascin e.g. thrombosis, cancer, wound healing and atherosclerosis.

25 The invention therefore provides pharmaceutical compositions for humans or veterinary compositions for animal use that comprise one or more of the aforementioned active fragments of tenascin-W. The compositions may also include other active or non-active agents. Non-active agents may include a pharmaceutically acceptable excipient, diluent or carrier, but not limited to  
30 saline, buffered saline, dextrose and water.

The compositions and medicaments of the invention may therefore be used prophylactically in order to prevent tumours from forming, or they may be used in a curative or partly curative way to treat or contain a pre-existing tumourous

condition. As well as tumours, cancerous or malignant conditions may be prevented or treated with compositions or medicaments of the invention.

In a particular aspect, the present invention provides the use of the nucleic

5 acid or proteins or polypeptides as hereinabove described, for  
radioimmunotherapy. Use of radiolabeled antibody is a promising approach to  
target radiotherapy directly into the tumor. Anti-tenascin-C antibodies are  
currently tested in phase I and II clinical trials. Patients with malignant gliomas  
were administrated locoregional radioimmunotherapy (LR-RIT) using <sup>131</sup>I-  
10 labeled anti-tenascin antibody injected directly in the tumor (Riva et al.,  
1999a). The first results show that LR-RIT can be safely performed, with good  
results especially in patients with minimal disease. Similar approach was  
performed with <sup>90</sup>Y (a pure beta emitter)-labeled antibodies Riva et al.,  
1999b), with promising results. Potentially more efficient  
15 radioimmunotherapies were shown to be possible using other isotopes, like in  
the case of an <sup>211</sup>At-labeled anti-tenascin antibody (Riva et al., 2001),  
without excessive toxicity for the patient. It is well a useful tool for precise  
imaging of tumors, since the presence of isotope is specifically targeted into the  
tumor allows sequential scintigraphies of the tumor (Riva et al., 1999a), and  
20 makes possible a direct estimation of the success of the therapy. Similar  
methodologies can be applied using antibodies specific for tenascin-W.

The tumours or tumour cells of the present invention are preferably those  
which express tenascin-W in the stroma. In particularly preferred

25 embodiments the tumours are solid tumours, e.g. mesenchymal tumours such  
as osteosarcoma, glioblastoma or epithelial cancers such as breast, prostate,  
lung and colorectal carcinoma.

The invention further provides the use of tenascin-W for the treatment or

30 prophylactic treatment of a condition ameliorated by the promotion of  
osteogenesis, e.g osteoporosis, osteoarthritis, treatment of cartilage and bone  
pathologies. A protein or polypeptide as hereinabove described may be used  
to be incorporated into implants including without limitation hip joints, knee  
joints, or broken bones, to promote osteogenesis.

The invention also provides a method of preventing or prophylactic treatment of tumourigenesis or of treatment or prophylactic treatment of tumours or cancer or of any one or more of rheumatism, asthma, allergic diseases,

5      autoimmune diseases, prevention of transplant rejection or the treatment or prophylactic treatment of any disease involving tenascin-W, e.g., thrombosis, wound healing and atherosclerosis in an individual comprising administering an effective amount of a tenascin-W or a fragment thereof.

10     The invention also provides a method of treatment or prophylactic treatment of a condition ameliorated by the promotion of osteogenesis, e.g osteoporosis, osteoarthritis, treatment of cartilage and bone pathologies in an individual comprising administering an effective amount of tenascin-W or a fragment thereof.

15     The determination of a suitable dose is well within the capability of those skilled in the art. For any compound, the therapeutically effective dose can be estimated initially either through cell culture assays or in an appropriate animal model. The animal model is also used to achieve a desirable concentration

20     range and route of administration. Such information can then be used to determine useful doses and routes for administration in humans.

A therapeutically effective dose refers to that amount of active agent which ameliorates the symptoms or condition. Therapeutic efficacy and toxicity of such compounds can be determined by standard pharmaceutical procedures in cell cultures or experimental animals (e.g., ED<sub>50</sub>, the dose therapeutically effective in 50% of the population; and LD<sub>50</sub>, the dose lethal to 50% of the population). The dose ratio between therapeutic and toxic effects is the therapeutic index, and it can be expressed as the ratio, LD<sub>50</sub>/ED<sub>50</sub>.

25     Pharmaceutical compositions which exhibit large therapeutic indices are preferred. The data obtained from cell culture assays and animal studies is used in formulating a range of dosage for human use. The dosage of such compounds lies preferably within a range of circulating concentrations that include the ED<sub>50</sub> with little or no toxicity. The dosage varies within this range

depending upon the dosage form employed, sensitivity of the patient, and the route of administration.

The exact dosage may be chosen by the individual physician in view of the patient to be treated. Dosage and administration can be adjusted to provide sufficient levels of the active moiety or to maintain the desired effect. Additional factors which may be taken into account include the severity of the disease state (e.g. tumour size and location); age, weight and gender of the patient; diet; time and frequency of administration; drug combination(s); reaction sensitivities; and tolerance/response to therapy. Long acting pharmaceutical compositions can be administered on a daily basis, every 3 to 4 days, every week, or once every two weeks, depending on half-life and clearance rate of the particular formulation.

15 The present inventors have observed stem cells, especially the periosteum, in the bone cell compartment for osteogenesis, expressing tenascin-W and therefore also encompassed by the invention is a method of the invention, wherein tenascin-W is used as a stem cell marker for cells including without limitation osteogenic precursor cells in the bone marrow. Therefore, also provided is a method of selecting stem cells or progenitor cells having the ability to differentiate into osteoblasts from other cells, not having this ability. Stem cells expressing tenascin-W can be detected by an antibody. The antibody recognizing tenascin-W can be detected using secondary antibodies specific for the tenascin-W antibody, which are optionally labelled with a radiolabel, an enzyme, avidin or biotin, or fluorescent materials (e.g. green fluorescent protein (GFP) or rhodamine), for example. The cells are characterized by having tenascin-W expression above basal levels and are preferably selected from a mixed population of cells using the fluorescence-activated cell sorter (FACS) (see for example Abe et al., Dev Biol. 1996; 180(2):468-72). The selected cells therefore carry a protein detectable by fluorescence. The sorted cells are useful for the production of biological parts of the body, e.g. bone tissue.

Also provided are antibodies that specifically recognizes tenascin W for use as a pharmaceutical, as well as for the manufacture of a medicament, for the prophylaxis or treatment of cancer (e.g., glioblastoma, prostate, lung, colorectal, osteo- or breast carcinoma), including metastatic cancer, or for the prophylaxis or treatment of any disease or condition involving tenascin-W, e.g. excessive bone growth. In another aspect of the present invention, an antibody specifically reactive against tenascin-W or a fragment thereof, and the use of an antibody for the manufacture of a medicament for the prophylaxis or treatment of cancer, and the antibody for use as pharmaceutical is provided.

Antibodies that specifically recognize tenascin-W or a fragment thereof are also provided, in particular antibodies that recognise the above mentioned epitope.

Methods for detecting tenascin-W embrace, for example, the use of an antibody as referred to above, optionally with the use of an enzyme reagent. The antibody recognizing tenascin-W can be detected using secondary antibodies specific for the tenascin-W antibody, which are optionally labelled with a radiolabel, an enzyme, avidin or biotin, or fluorescent materials (FITC or rhodamine), for example.

Also encompassed by the invention is the use of an antibody that specifically recognizes tenascin-W for the manufacture of a medicament, in particular a medicament for the prophylaxis or treatment of cancer, the prophylaxis or treatment of bone disease, or as a pharmaceutical. In particularly encompassed by the invention is the use of an antibody that specifically recognizes tenascin-W for the diagnosis of tumour, especially metastatic tumour.

In a further embodiment, the present invention provides a method for identifying agents for the prevention or the prophylactic treatment of tumourigenesis or the treatment or prophylactic treatment of tumours or cancer, or the treatment or prophylactic treatment of any disease or condition

involving tenascin-W, e.g. a condition ameliorated by the promotion (or inhibition) of osteogenesis, comprising contacting a test compound with a tenascin-W expressing sample and then measuring a change in one or more of (a) cell proliferation, e.g. cell progression entering S-phase of the cell cycle;

5 (b) DNA synthesis; (c) cell adhesion; (d) cell spreading; (e) focal adhesion and actin stress fibre formation on fibronectin; (f) cell binding to extracellular matrix (ECM), relative to when said test compound is absent.

Cells may be encouraged to proliferate by the addition of tenascin-W to the

10 cell culture, preferably by coating the solid substrate therewith. A substrate can be any surface that promotes cell adhesion. The solid substrate may also be coated by other ECM which include without limitation fibronectin, collagen, etc. The cell cultures are preferably grown on a solid substrate or in a liquid medium. A first measurement of one or more of (a) to (f) may be made prior  
15 to contacting the cells with a test substance. A second measurement may be made thereafter. A multiplicity of further measurements may be made over a period of hours or days after contact of the cells with the test compound. In this way a time course of the cellular response(s) may be determined and analysed.

20 In one preferred embodiment of the present invention, the presence of tenascin-W in the liquid medium is measured relative to when a test compound is absent. An increase in the level of tenascin-W present in the medium relative to when said test agent is absent correlates to an agent effective in the promotion of osteogenesis, for example. A decrease in the level of tenascin-W present in the medium relative to when said test agent is absent correlates to an anti-proliferative or anti-tumour agent, or an agent effective in inhibiting osteogenesis or osteoblast formation.

25

30 In preferred aspects one or more of the following conditions arising after contacting cells with a test compound is indicative of an anti-proliferative or anti-tumour agent, or an inhibitor of osteoblast formation:

(a) a reduction in cell proliferation; or a decrease in the proportion of cells entering S-phase of the cell cycle;

(b) a reduction in DNA synthesis;

(c) an increase in cell adhesion;

5 (d) an increase in cell spreading;

(e) an increase in focal adhesion and actin stress fibre formation on fibronectin; and

(f) an increase in the binding of cells to ECM, preferably fibronectin;

10

In other preferred aspects one or more of the following conditions arising after contacting cells with a test compound may indicate an osteogenesis promoting agent:

15 (a) an increase in cell proliferation; or an increase in the proportion of cells entering S-phase of the cell cycle;

(b) an increase in DNA synthesis;

(c) and (d) an increase in the expression of bone-specific markers such as alkaline phosphatase activity, calcification or any others known in the art (e.g., Raouf and Seth, 2002, Bone 30: 463-71).

20

Actin stress fibre formation may be assayed according to the Actin Assembly Assay described in Bloom, L *et al* (1999) Mol Biol Cell 10: 1521-1536. Adhesion assays may be performed according to the method described in Bloom, L *et al* (1999).

25 In other embodiments, the method of the invention may further comprise control cells grown in the absence of test substance and (a), (b), (c), (d), (e), and/or (f) are measured in both control and test cultures. The test measurements can thereby be normalised with respect to the control.

30 The screening method further provides an essentially cell-free system for the identification of potential anti-tumour or tumour preventing agents or for an agent inhibiting osteogenesis. This method relies on the ability of a potential

anti-tumour agent to prevent, inhibit or disrupt the binding between an ECM and tenascin-W. The nature of any disruption of the ECM and tenascin-W binding may be determined by performing a binding assay for ECM and tenascin (see e.g. example 10). For example, calorimetric methods may be  
5 used or measurement of labelled reagents.

Alternatively, a method is provided for identifying modulators of tenascin W function, comprising: (a) contacting a test compound with tenascin W and/or alpha8 beta1 integrin, and (b) measuring the binding of the test compound to  
10 tenascin-W and/or alpha8 beta1 integrin, or (c) measuring a disruption of binding of tenascin-W to alpha8 beta1 integrin, relative to when the test compound is absent. A decrease in binding of tenascin-W to alpha8 beta1 integrin is indicative of an inhibitor of this interaction, and increased binding could indicated that the test compound activates the alpha8 beta1 integrin,  
15 thereby increasing the interaction between tenascin-W and alpha8 beta1.

The relative amounts or concentrations of reagents and test substance may be measured thereby permitting calculation of inhibition constants and other parameters, e.g. binding affinities. The optimisation of assay conditions will  
20 be well within the realm of one of ordinary skill in the art. The system may further comprise a control without test substance and the binding is measured in the control, thereby permitting corresponding measurements in the test system to be normalised relative to the control.

25 Where one component of the assay (screening) systems of the invention is coupled to a solid particle or substrate, then one or more of the other components not so coupled may be labelled. Examples of labels include radiolabels e.g. <sup>14</sup>C or <sup>3</sup>H, dyes, metal sols, enzymes or biotin/avidin. By attaching such labels to "free" components in the system any binding assay  
30 may be carried out in solution in accordance with procedures well known in the art. After allowing the components to react solid phase particles can be separated from solution, e.g. by filtration or sedimentation (including centrifugation). In some embodiments immunoprecipitation may be used to separate bound and free labelled components. Usually, an antibody may be

employed to bring an unlabelled component out of solution (whether or not this component has bound to another labelled component or not). After separation, the label present in solution (free) and the label present in or on the solid phase (bound) may be measured. Standard analyses of such bound and free data, e.g. Scatchard plots and the determination of affinity and inhibition constants for binding are well known to the person of ordinary skill in the art.

Where the solid phase is not particulate, e.g. in the form of a surface, such as a microtiter plate well, then binding assays measuring bound and free label may be performed but this will normally involve the removal of liquid phase from the wells after binding reactions have occurred. Advantageously, this assay format may dispense with the need for providing specifically labelled reaction components. Instead, labelled antibodies may be used to measure the binding of previously free reaction components to solid phase components.

In some embodiments the tenascin-W molecule, variant or fragment thereof may be attached directly to a solid phase. In preferred immunoassay embodiments of this type, tenascin-W bound to an ECM is measured using an antibody reactive against tenascin-W.

Immunological binding assays are known in the art. For a review, see Methods in Cell Biology Vol. 37: Antibodies in Cell Biology, Asai, (Ed.) Academic Press, Inc. New York (1993).

A label may be any detectable composition whereby the detection can be spectroscopic, photochemical, biochemical, immunochemical, physical or chemical. For example, useful labels can include  $^{32}\text{P}$ ,  $^{35}\text{S}$ ,  $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^{125}\text{I}$ ,  $^{131}\text{I}$ , fluorescent dyes (e.g. FITC, rhodamine and lanthanide phosphors), electron-dense reagents, enzymes, e.g. as commonly used in ELISA (e.g. horseradish peroxidase, beta-galactosidase, luciferase and alkaline phosphatase), biotin, dioxigenin, or haptens and proteins for which antisera or monoclonal antibodies are available. The label may be directly incorporated into a target

compound to be detected, or it may be attached to a probe or antibody which binds to the target.

Throughout the assays of the invention, incubation and/or washing steps may  
5 be required after each application of reagent or incubation of combinations of reagents. Incubation steps may vary from about 5 minutes to several hours, perhaps from about 30 minutes to about 6 hours. However, the incubation time usually depends upon the assay format, analyte, volume of solution, concentrations, and so forth. Usually, the assays should be carried out at  
10 ambient temperature, although they may be conducted at temperatures; in the range 10°C to 40°C, for example.

A particularly preferred assay format is an enzyme-linked immunosorbent assay (ELISA).

15 All of the aforementioned methods of screening of the invention are equally applicable to the screening of substances for biological activity and potential agents for any other disease or condition involving tenascin-W, e.g. wound healing or treatment of atherosclerosis.

20 Also included within the scope of the present invention are anti-tumourigenic, anti-tumour, anti-metastatic, (anti-)osteogenic, wound healing or anti-  
25 atherosclerosis substances or substances for the treatment or prophylactic treatment of any disease or condition involving tenascin-W identified by any of the screening methods of the invention. These substances may be proteins, polypeptides or small organic molecules (drugs). The invention therefore includes pharmaceutical compositions for preventing or treating tumours, metastasis, or bone pathologies and comprising one or more of the substances identified by a method of the invention. For example, inhibitors of  
30 tenascin-W expression or activity are considered potential anti-cancer agents, whereas tenascin W or agonists thereof are considered agents effective in promoting osteogenesis, which can be used in vivo or ex vivo.

Thus, the present invention provides a novel mammalian member of the tenascin family and uses thereof. It permits the identification of agents effective against conditions dependent on tenascin-W, in particular anti-cancer agents or agents that promote osteogenesis, by performance of any of the

5 methods of screening described herein. Preferred anti-cancer agents are those which inhibit proliferation of the cancer cells and which may be general anti-proliferative agents.

The invention includes all nucleic acid molecules and proteins and

10 polypeptides as hereinabove described, as well as agents identified by performing the methods, and the use of these agents as pharmaceuticals, particularly as medicaments for the prophylaxis or treatment of cancer and other conditions dependent on tenascin W.

15 Thus, in a further aspect the invention provides for the use of tenascin-W and of an agent identified by a screening method of the invention as a pharmaceutical.

20 The invention further provides tenascin-W or an agent identified by a screening method of the invention, for the manufacture of a medicament for the prophylaxis or treatment of a condition dependent on tenascin-W, for use to treat cancer or bone diseases or an immunological defect.

25 The invention provides a method of preventing or treating a condition dependent on tenascin-W comprising administering to an individual an effective amount of a construct, vector, host cell or antibody described above.

30 The invention also provides a method of inhibiting a condition dependent on tenascin-W comprising administering an effective amount of the modulator identified by a screening method of the invention described above, for the treatment of cancer or bone disease or an immunological defect.

Also provided by the invention are the nucleic acid molecules, the proteins, and the agents referred to above in a pharmaceutical composition, possibly in

the presence of suitable excipients known to one of ordinary skill in the art. The compositions may be administered in the form of any suitable composition as detailed below by any suitable method of administration within the knowledge of a skilled man. The preferred route of administration is

5 parenterally. In parenteral administration, the compositions of this invention will be formulated in a unit dosage injectable form such as a solution, suspension or emulsion, in association with a pharmaceutically acceptable excipient. Such excipients are inherently nontoxic and nontherapeutic. Examples of such excipients are saline, Ringer's solution, dextrose solution  
10 and Hank's solution. Nonaqueous excipients such as fixed oils and ethyl oleate may also be used. A preferred excipient is 5% dextrose in saline. The excipient may contain minor amounts of additives such as substances that enhance isotonicity and chemical stability, including buffers and preservatives.

15 Any protein is administered at a concentration that is therapeutically effective to prevent organ rejection, GVHD, allergy and autoimmune diseases. The dosage and mode of administration will depend on the individual. Generally, the compositions are administered so that the functional protein is given at a dose between 1 pg/kg and 10 mg/kg, more preferably between 10 ug/kg and  
20 5 mg/kg, most preferably between 0.1 and 2 mg/kg. Preferably, it is given as a bolus dose. Continuous short time infusion (during 30 minutes) may also be used. The compositions according to the invention may be infused at a dose between 5 and 20  $\mu$ g/kg/minute, more preferably between 7 and 15  $\mu$ g/kg/minute.

25 According to a specific case, the "therapeutically effective amount" of a composition needed should be determined as being the amount sufficient to cure the patient in need of treatment or at least to partially arrest the disease and its complications. Amounts effective for such use will depend on the  
30 severity of the disease and the general state of the patient's health. Single or multiple administrations may be required depending on the dosage and frequency as required and tolerated by the patient.

The present invention also provides a method of diagnosing or prognosing cancer, or any other condition dependent on elevated tenascin W levels, comprising, (a) analysing a sample obtained from an individual for the presence of tenascin-W; and (b) correlating the presence of tenascin-W with 5 an unfavourable prognosis or diagnosis.

The methods of the present invention will typically involve the determination of the presence, level, or activity of tenascin-W in a cell or tissue sample, which sample will often be obtained from a human, but one can also readily 10 understand that samples tested by the present method can be obtained from agriculturally important mammals, such as cattle, horses, sheep, etc., or other animals of veterinary interest, such as cats and dogs. The assay may be carried out on any cell or tissue sample, such as somatic tissues, germline tissues, or cancerous tissues, as well as on samples from body fluids, such as 15 pleural fluid, blood, serum, plasma and urine. The method may also further comprise propagating cells in the sample in cell culture.

A "sample" is the material being analyzed which is usually, but not necessarily, subjected to pretreatment to provide the tenascin-W in assayable 20 form. This would for example, entail forming a cell extract, methods for which are known in the art (for example, see Scopes, Protein Purification: Principles and Practice, Second Edition (Springer-Verlag, N.Y., 1987)).

In the broader aspects of the invention, there is no limitation on the collection 25 and handling of samples as long as consistency is maintained. The sample is obtained by methods known in the art, such as, biopsies, surgical resections, smears, or the like. Optionally, cells obtained in a sample may be propagated in cell culture.

30 Consistency of measurement of tenascin-W or tenascin-W activity in clinical samples can be ensured by using a variety of techniques. For example, to control for the quality of each tissue extract, another enzymatic activity, such as alkaline phosphatase, can serve as an internal control. In addition, an internal standard can be measured concurrently with tenascin-W in the

sample as a control for assay conditions. Thus, the analyzing step can comprise detecting a control protein in the sample, optionally normalizing the value obtained for tenascin-W with a signal obtained with the control protein.

- 5      The presence of tenascin-W in the sample can be determined by detecting the tenascin-W protein using methods known in the art. In this invention, there are no limitations on the type of assay used to measure tenascin-W or tenascin-W activity. For example, tenascin-W can be detected by immunoassays using antibodies specific for tenascin-W. The antibody can be used, for example, in
- 10     Western blots of two dimensional gels where the protein is identified by enzyme linked immunoassay or in dot blot (Antibody Sandwich) assays of total cellular protein, or partially purified protein.

Methods for sample concentration and protein purification are described in the literature (see Scopes, 1987). For example, if desired, the tenascin-W present in the cell extract can be concentrated, by precipitating with ammonium sulfate or by passing the extract through a commercially available protein concentration filter, e.g., an Amicon or Millipore, ultrafiltration unit. The extract can be applied to a suitable purification matrix, such as an anion or a cation exchange resin, or a gel filtration matrix, or subjected to preparative gel electrophoresis. In such cases, the tenascin-W and protein yield after each purification step needs to be considered in determining the amount of tenascin-W in a sample.

- 25     Tenascin-W may be detected using an antibody specific for tenascin-W, and a control assay can be carried out using an antibody specific for another tenascin molecule. Optionally, the method may further comprise correlating in an increase in tenascin-W in the sample relative to healthy tissue. For example, tenascin-W can be detected using an antibody specific for tenascin-W expressed in tumour tissue and compared to antibody binding to any tenascin-W expressed (or non-specific reaction) in healthy tissue.
- 30

The sample is preferably a tissue sample mounted onto a solid surface for histochemical analysis. The presence of detectable, accessible tenascin-W

indicates that tenascin-W is accessible to cells for binding. This leads to a unfavourable diagnosis or prognosis. If, on the other hand, the antibody does not react with tenascin-W in the tissue section, then there is an expectation that tenascin-W is not present. This leads to a favourable diagnosis or  
5 prognosis.

The present inventors have found that tenascin-W is specifically expressed in solid tumours, in particular metastatic tumour tissue or stroma thereof. The presence of tenascin-W therefore indicates a cancerous condition, in  
10 particular the presence of metastatic tumour tissue, whereas the absence of tenascin-W indicates healthy tissue or non-metastatic tumour tissue. Tenascin-W was identified in developing mouse tissues by western blotting. High expression of tenascin-W was found in the metastatic tumours of ras-transgenic mice, but not in the myc- or neuT-transformed non-metastatic  
15 tumours. The presence of tenascin-W (170 kD) is indicative of unfavourable diagnosis.

In a further embodiment, the diagnostic or prognostic methods of the invention further comprises analysing the sample for the presence of alpha 8 integrin, the presence of alpha 8 integrin correlating with an unfavourable prognosis or diagnosis. This can easily be achieved, for example, using an antibody as described in detail in Example 8 below.

In a preferred embodiment, the invention provides kits suitable for use in the  
25 diagnostic or prognostic methods of the invention. Such kits comprise reagents useful for carrying out these methods, for example, antibodies from one or more species specific for tenascin-W and alpha 8 beta1 integrin. Secondary antibodies that recognise either or both such primary anti-fibronectin antibodies can also be included for the purpose of recognition and  
30 detection of primary antibody binding to a sample. Such secondary antibodies can be labelled for detection e.g. with fluorophores, enzymes, radioactive labels or otherwise. Other detection labels will occur to those skilled in the art. Alternatively, the primary anti-tenascin-W antibodies can be labelled for direct detection.

The invention is further described below, for the purpose of illustration only, in the following examples.

5   **Example 1: Cloning of mouse tenascin-W**

Mouse tenascin-W was cloned from a cDNA library of 19d whole mouse embryos (DupLEX-A DLM-110; OriGene Inc.). In a first step the following PCR primers derived from a sequence from chromosome 1, similar to Tenascin-R (Accession number AL049689) were used for nested PCR reactions with the

10   **Expand High Fidelity PCR System (Roche)** using the mouse cDNA library as template. The first reaction was performed with the primer set 5'-  
TAGCAGCCCACAGCATCTACTGCC-3' (SEQ ID NO:5) / 5'-  
ATTGCTGTTCTGCTAACCTGACTGCA -3' (SEQ ID NO:6) and the second reaction with 5'-ATGGATCCAGAAATTGACGGCCCCAAAAACCTAG-3' (SEQ  
15   ID NO:7) / 5'-ATAAGCTTGTGGAGAGGGTGGATACATTC-3' (SEQ ID NO:8). The second primer set included a BamHI and a HindIII restriction site, respectively, to allow site-directed cloning into the bacterial expression vector pQE30~~(lacZα)~~, employing a C-terminal His-tag for the purification of the recombinant proteins.

20   The mouse proteins (tenascin W polypeptide fragments obtained as a result of the above procedure) were expressed in *E. coli* and purified by affinity chromatography to a Ni-NTA matrix (Qiagen) according to the matrix supplier's manual. The protein was purified under native conditions and was  
25   eluted with 250mM imidazole.

Full length tenascin-W was cloned by the use of mouse tenascin-W specific primers derived from the above mouse tenascin-W cDNA and primers matching the vector of the same 19d whole mouse embryo cDNA library used  
30   before. To obtain the complete 5' sequences, the following PCR reactions using the above cDNA as template were performed: The first PCR reaction was performed using the primer pair 5'-AGGAGATGGTGGCTGTATTTCGG-3' (SEQ ID NO:9) / 5'-AGCCTCTTGCTGAGTGGAGATGCC-3' (SEQ ID NO:10) followed by a second PCR reaction with the primer set 5'-

TAGAATTCGGTACCTGATTGGTCAGTAGG-3' (SEQ ID NO:11) / 5'-TTATGATGTGCCAGATTATGCC-3' (SEQ ID NO:12). To complete the 3' part of the tenascin-W cDNA the following PCR reactions were performed: In the first reaction the primer pair 5'-CTCAAATTGATGGCTACATTTGACC-3' (SEQ ID NO:13) / 5'-AAGCCGACAAACCTTGATTGGAGAC-3' (SEQ ID NO:14) was used followed by the primer pair 5'-TACCAAGTCCCAAATGGCACCG-3' (SEQ ID NO:15) / 5'-AACACTCTGGCGAAGAAGTCC-3' (SEQ ID NO:16). In each case the longest products were cloned. These overlapping tenascin-W cDNA clones were assembled into one full length mouse tenascin-W cDNA and cloned into the expression vector pCEP/Pu (see Kohfeldt et al. (1997). FEBS Lett. 414:557-61). At the 3'end of the tenascin-W cDNA a 6xHis-tag was inserted in front of the stop codon to allow the purification of full length mouse tenascin-W protein expressed in mammalian cell culture.

15 The recombinant mouse tenascin-W protein comprises three C-terminal fibronectin type III repeats in the region defined by amino acids 794-1057 of the complete amino acid sequence of mouse tenascin-W, encoded by nucleotides 2380 – 3171 of the tenascin-W nucleotide sequence.

20 **Example 2: Characterization of mouse Tenascin-W**  
The full length cDNA of mouse tenascin-W was cloned as described in example 1. The cDNA sequence encodes a typical member of the tenascin protein family and harbors from the N-terminus to the C-terminus of the protein the following structural domains: signal peptide for secretion, N-terminal domain for dimerisation of two tenascin-W trimers that are assembled by heptad repeats. This results in a disulfide-linked hexameric protein complex where each subunit contains three and a half EGF-like repeats, nine fibronectin type III repeats, and a fibrinogen-like C-terminal globular domain.

25

30 The full length tenascin-W cDNA was transfected into HEK 293 cells using the transfection reagent fugene (Roche). Transfected cells were selected with puromycin and the medium containing the secreted tenascin-W protein was collected and the protein was purified by sequential chromatography over a gelatin-agarose column (Sigma) to remove any contaminating fibronectin in

the preparation and by adsorption to a Ni-NTA matrix (Qiagen). The tenascin-W was eluted from the nickel column by 250mM imidazole.

The recombinant protein was also analyzed by SDS-PAGE (sodium dodecyl sulfate - polyacrylamide gel electrophoresis) on 6% polyacrylamide gels, under reducing and non-reducing conditions as well as by electron microscopy after rotary shadowing using the same procedure as described for tenascin-C (Chiquet-Ehrismann, R. et al. (1988) *Cell* **53**, 383 – 390). Tenascin-W showed a similarly slow migration as the hexameric tenascin-C protein. Electronmicrographs of tenascin-W after rotary shadowing indeed revealed hexameric molecules with six subunits of about 50nm length radiating from a central globular domain.

### **Example 3: Cloning of human tenascin-W**

Human tenascin-W was cloned from cDNA made from mRNA isolated from the osteosarcoma cell line Saos-2 (ATCC; HTB 85) essentially as described in Example 1 using the same PCR primers. The human protein was expressed and purified by affinity chromatography to a Ni-NTA matrix (Qiagen) according to the matrix supplier's manual. The protein was purified under native conditions and was eluted with 250mM imidazole.

The recombinant protein comprises the three C-terminal fibronectin type III repeats in the region defined by amino acids 791-1054 of the complete amino acid sequence of human tenascin-W encoded by nucleotides 2371 – 3163 of the tenascin-W nucleotide sequence of the database entry AL049689), respectively.

Full length tenascin-W is cloned by the use of human tenascin-W specific primers derived from the above human tenascin-W cDNA and human genomic sequences 5' to the ATG start codon of the cDNA sequence entry AL049689 using cDNA made from mRNA isolated from osteosarcoma cell line Saos-2 (ATCC; HTB 85) as the template. The following primers are used for three sets of nested PCRs:

hTNW1: 5'CATCCTGGAGGGTCTGCTCC3' (SEQ ID NO:17)

hTNW2: 5'GGGCATTGGTGTCAAGCTTC3' (SEQ ID NO:18)  
hTNW3: 5'GACTCGAGCTTCCAAGGATGAGTCTCC3' (SEQ ID NO:19)  
hTNW4: 5'GAGGATCCCCTGGTTGCCCTTCAG3' (SEQ ID NO:20)  
hTNW5: 5'GCGCTACACTCTGCTGATG3' (SEQ ID NO:21)

5 hTNW6: 5'CTGTGGAGAGGGTGGTGG3' (SEQ ID NO:22)  
hTNW7: 5'GACTCGAGTGCACAAGGATGAGAGCAG3' (SEQ ID NO:23)  
hTNW8: 5'GAGGATCCACCCTAAAGGCAACAAGGG3' (SEQ ID NO:24)  
hTNW8: 5'GAGGATCCACCCTAAAGGCAACAAGGG3' (SEQ ID NO:24)  
hTNW9: 5'CGCAGTCTGGTGGCATATTG3' (SEQ ID NO:25)

10 hTNW10: 5'CATGATTGTTCTGCGGGC3' (SEQ ID NO:26)  
hTNW11: 5'GACTCGAGCGGCTACATTCTGACTTACC3' (SEQ ID NO:27)  
hTNW12: 5'GAGGATCCTCAGTGATGGTATGGTGATG3' (SEQ ID NO:28)  
The following PCR reactions are performed using for fragment A primer  
combinations hTNW1/ hTNW2 followed by hTNW3/ hTNW4, for fragment B  
15 hTNW5/ hTNW6 followed by hTNW7/ hTNW8 and for fragment C hTNW9/  
hTNW10 followed by hTNW11/ hTNW12. These fragments can be  
joined together to make up the full length human tenascin-W by digesting  
fragment A with Xhol and Accl, fragment B with Accl/NarI and fragment C with  
NarI/BamHI and cloning the ligated assembly into the Xhol/BamHI sites of the  
20 expression vector pCEP/Pu (see Kohfeldt et al. (1997) FEBS Lett. 414:557-  
61). At the 3'end of the human tenascin-W cDNA a 6xHis-tag was inserted in  
front of the stop codon for ease of purification upon expression in mammalian  
cell culture. Human tenascin-W is purified as described for mouse tenascin-W  
(example 2).

25

**Example 4: Antibody production, immunohistochemistry and  
immunoblots: Expression of tenascin-W during development**

The bacterially expressed recombinant fragment of mouse tenascin-W as  
30 described above in Example 1, was used to raise polyclonal antisera in rabbits  
using standard immunization procedures. These antisera were used to detect  
tenascin-W in tissue extracts and cryosections of developing mouse embryos  
using methods described for tenascin-Y (Hagios, C. et al. (1996) J. Cell Biol.  
134, 1499-1512). The antiserum reacted specifically with purified full-length

recombinant tenascin-W as well as with endogenous tenascin-W in tissue extracts of mouse organs, as demonstrated by Western blotting. In both cases, tenascin-W was identified as a 170kDa molecular weight species.

- 5      The anti-tenascin-W antiserum was used to investigate tenascin-W expression during normal mouse development by immunohistochemistry. For immunohistochemistry, tissues were fixed in ice-cold 4% paraformaldehyde in phosphate-buffered saline (PBS) overnight, washed with PBS and cryoprotected with 25% sucrose in PBS overnight at 4°C. The tissues were
- 10     embedded in OCT (Optimal Cutting Temperature) mounting medium (Cat. No. 27050 OCT Compound by Ted Pella Inc., CA) and sections of 12-16µm were cut and collected onto glass slides. The sections were air-dried for 2 hours before staining with anti-tenascin-W antiserum followed by a fluorescently labelled secondary antibody.
- 15     Tenascin-W first appears at embryonic day 11.5 (E11.5) in the maxillary process. Between E14.5 and E16.5, tenascin-W and tenascin-C expression overlaps in developing connective tissue (palate and mandible) in the face and jaw. Furthermore tenascin-W is found in the extracellular matrix (ECM) of smooth muscle, mesothelia and bone. In the adult mouse tenascin-W is found in a subset of the tenascin-C-positive ECM of the aortic valve and the limbus. In these locations its expression coincides with the stem cell compartment of the respective tissue. Tenascin-W is also expressed in the periosteum, the stem cell compartment for osteogenesis. Tenascin-W is also expressed in kidney and the digestive tract in a subset of tenascin-C-positive regions, but not in the brain.

#### **Example 5: Monoclonal antibodies against human tenascin-W**

- 30     The bacterially expressed recombinant fragment of human tenascin-W as described above in Example 3 was used to raise monoclonal antibodies against human tenascin-W using standard procedures. The monoclonal antibodies reacted specifically with human tenascin-W having better binding

than relying on the crossreactivity of the anti-mouse tenascin-W for human tenascin-W. The monoclonal antibodies are particularly useful to stain human tissues.

5   **Example 6: Tenascin-W expression in tumour cells**

Tenascin-W expression in tumour cells was tested and compared with the known results for tenascin-C which has been found to be highly expressed in tumour tissues (Chiquet-Ehrismann, R. (1993) Sem. Cancer Biol. 4, 301-310).

Mouse mammary tumours develop readily in transgenic mice expressing

10   oncogenes under the control of mammary gland-specific promoters.

Overexpression of c-myc results in the growth of non-metastatic tumours whereas overexpression of Ha-ras leads to the development of metastatic tumours (Li, F. et al. (1994) Int. J. Cancer 59, 560-568).

15   In this Example, the antisera described in Example 4 were used to detect tenascin-W in mouse mammary tumours as described for tenascin-Y by Nagy, C. et al. (1996). High expression of tenascin-W (about 170 kDa) was found in the tumours of ras-transgenic mice (metastatic), but not in the myc- or neuT-transformed non-metastatic tumours, whereas tenascin-C was over-expressed in both types of tumours.

As a control, expression of tenascin-W was examined in healthy tissue, using blood serum, for example. The content of tenascin-W in serum is analyzed by Western blotting. For improved sensitivity a Sandwich ELISA test as described previously for tenascin-C (Schenk et al. 1995. Int. J. Cancer 61:443-449) can be used. Briefly, 96-well plates are coated with either polyclonal or monoclonal anti-tenascin-W antibodies. The serum samples are applied, the wells washed and the bound tenascin-W is detected by either a polyclonal or a monoclonal anti-tenascin-W antibody followed by an appropriate peroxidase-labeled secondary antibody. No expression of Tenascin-W was found in blood serum from wild-type mice. In contrast, healthy kidney, heart valve and periosteum was found to express Tenascin-W.

Transgenic mice overexpressing neuT develop non-metastasizing mammary tumours, whereas in transgenic mice overexpressing neuT together with EphB4 receptor tyrosine kinase the tumours are metastatic (Munarini, N. et al. (2002) *Cell Sci.* **115**, 25-37). Using this model system we again found high expression of tenascin-W in metastatic tumours, but not in non-metastatic ones. These expression patterns were confirmed by SDS-PAGE (SDS-polyacrylamide gel electrophoresis), by fractionating tumour extracts, blotting on polyvinylidene difluoride membranes, and analyzing the extract using anti-tenascin-W antisera.

10

**Example 7: Adhesion assay**

The purified tenascin-W was used for cell adhesion studies of MDA-MB435 mammary carcinoma cells (ATTC; HTB-129), C2C12 mouse skeletal myoblasts (ATTC; CRL-1772, T98G glioblastoma cells (ATTC; CRL-1690) and NIH-3T3 fibroblasts (ATTC; CRL-1658). In brief, 60-well microtiter plates (Nunc) were coated with 2-100 µg/ml tenascin-W for 1h at 37°C. The coated plastic surface was blocked with 1% heat-inactivated BSA in PBS. Cells were trypsinised, trypsin was blocked with 100µg/ml soybean inhibitor in PBS and, cells were resuspended in serum-free medium and counted. 200-500 cells per well were plated for the indicated time points, fixed by addition of glutaraldehyde (2% final concentration) for 15 minutes and stained with 0.1% crystalviolet in 20% methanol for 30 minutes. Cells were observed under a microscope (Nikon diaphot).

25 Most cells adhered to tenascin-W coated at 2-100 µg, whereas cell adhesion to tenascin-C was minimal.

We compared the morphology and actin cytoskeleton of C2C12 mouse skeletal myoblasts and T98G glioblastoma plated on tenascin-W to cells plated on fibronectin or tenascin-C. The shape of the cells on tenascin-W was very different from the cells on fibronectin, which became particularly evident after F-actin staining with phalloidin. The cells on fibronectin were well spread containing stress fibers, whereas the cells on tenascin-W had many actin-rich processes but no stress fibers and the cell bodies remained relatively round.

**Example 8: Identification of a cellular tenascin-W receptor**

To determine the cellular receptor(s) responsible for cell adhesion to tenascin-W, we tested the effect of integrin function-blocking antibodies on adhesion of T98G glioblastoma cells on tenascin-W. Antibodies to  $\alpha 1$ ,  $\alpha 2$ ,  $\alpha 3$ ,  $\alpha 4$ ,  $\alpha 5$ ,  $\alpha 6$  and  $\alpha V$  were unable to inhibit adhesion of T98G cells to tenascin-W. Nevertheless, this adhesion was  $\beta 1$  integrin-dependent since 10  $\mu\text{g}/\text{ml}$  of the anti- $\beta 1$  integrin blocking antibody P4C10 (Sigma) was able to completely inhibit adhesion to tenascin-W.

IDG tripeptide motifs have been reported to be the recognition sequence for alpha9 beta1 integrin (Yokosaki et al., 1998). Since mouse tenascin-W contains three IDG motifs we investigated whether  $\alpha 9$  integrin could be the receptor for tenascin-W. We plated SW480 colon carcinoma cells transfected either with an empty vector or with the vector containing the cDNA for  $\alpha 9$  integrin (Yokosaki et al. J Biol Chem. 1998 Sep 27;273(38):24144-50) on tenascin-W coated wells. However, the  $\alpha 9$  integrin-transfected SW480 cells failed to adhere to tenascin-W whereas they adhered well to fibronectin and collagen.

Integrin  $\alpha 8$  is expressed in developing rib bone, in kidney and in smooth muscle from the gastro-intestinal tract (Denda et al. Biochemistry. 1998 Apr 21;37(16):5464-74). Since this expression pattern coincides with the presence of tenascin-W it seemed that integrin  $\alpha 8$  was a good candidate receptor for tenascin-W as well. We tested this hypothesis by using the leukemia cell line K562, transfected with  $\alpha 8$  integrin (Denda et al. Biochemistry. 1998 Apr 21;37(16):5464-74). Transfected K562 cells could indeed adhere to tenascin-W and the mock-transfected control cells did not. Therefore,  $\alpha 8\beta 1$  integrin is a receptor for tenascin-W.

**Example 9: DNA replication and proliferation assay**

96-well plates (Falcon) are coated as described above. Cells are serum starved overnight and trypsinised.  $10^4$  cells are transferred onto the coated

plates in the presence of 1 % serum or 40nM PDGF BB (Platelet-derived growth factor BB). 14h later cells are labelled with radioactive  $^3\text{H}$ -thymidine ( $0.5\mu\text{Ci}/\text{well}$ ) for 4h at  $37^\circ\text{C}$ , incorporated  $^3\text{H}$ -thymidine precipitated with 10% TCA and determined with a Beckman scintillation counter after cell lysis in 5 0.3N NaOH, 2% SDS. Alternatively, incorporation of BrdU is measured or cells numbers are counted over a growth period of several days of cells plated on different substrates. Cancer cells grown on tenascin-W show an increased growth rate over cells plated on fibronectin, as established by counting cells or an increase in radioactive  $^3\text{H}$ -thymidine or BrdU incorporation into cellular 10 RNA.

**Example 10: In vitro binding assay (ELISA)**

96-well ELISA plates are coated with the appropriate ECM proteins (e.g. fibronectin or tenascin-W) for 1h at  $37^\circ\text{C}$ , blocked with 1% milkpowder, 0.05% 15 Tween-20 in PBS. ECM proteins (tenascin-W or fibronectin) are added in blocking solution with blocking solution and the appropriate antibodies are added. In this example, an interaction between tenascin-W and fibronectin can be detected. Bound proteins are detected by immune reaction with a peroxidase-coupled secondary antibody followed by 20 colour reaction with 21mg/ml citric acid 1-hydrate, 34mg/ml  $\text{Na}_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$ , 0.4mg/ml phenylenediamine, 1 $\mu\text{l}$   $\text{H}_2\text{O}_2$ , which can be stopped with 4M sulphuric acid. The absorbance was read at 590nm.

**Example 11: Immunofluorescence microscopy**

25  $10^4$  cells are transferred onto 4-well Cellstar plastic plates (Greiner) that are coated with ECM proteins essentially as described above. Cells are fixed with 4% paraformaldehyde, 50mM phosphate buffer, 5mM EDTA in PBS for 15 minutes, blocked with 3% BSA, 0.5% Tween-20 in PBS and incubated with primary and secondary antibodies in blocking solution. Slides are embedded 30 in 10.5% Mowiol containing 2.5% DABCO as antifade agent. Cells are analysed by microscopy. This method is particularly useful for the detection of tenascin-W or any other protein produced by cells in culture to which an antibody is available and can be used to analyze substances that affect the synthesis or deposition of the respective antigens.

As is apparent to one of ordinary skill in the art, variations in the above-described methods can be introduced with ease to attain the same objective.

- 5 Various incubating conditions, labels, apparatus and materials can be chosen according to individual preference. All publications referred to herein are incorporated by reference in their entirety as if each were referred to individually.

CLAIMS:

1. An isolated nucleic acid molecule having:
  - (a) a nucleotide sequence as set forth in SEQ ID NO: 1;
  - (b) a nucleotide sequence encoding a polypeptide having the amino acid sequence shown in SEQ ID NO: 2;
  - (c) a nucleotide sequence with at least 85% identity to the sequence of (a) or (b);
  - (d) a subsequence of a least 50 consecutive nucleotides of a sequence of (a), (b) or (c), with the proviso that said subsequence does not fall between nucleotide 1027 and nucleotide 1076 of SEQ ID NO: 1; or
  - (e) a nucleotide sequence complementary to any of the nucleotide sequences in (a),(b), (c) or (d).
2. The nucleic acid of claim 1 having said nucleotide sequence with at least 85% identity to the sequence of (a) or (b).
3. The nucleic acid of claim 1 encoding a polypeptide having the amino acid sequence shown in SEQ ID NO: 2.
4. The nucleic acid of claim 1, having a subsequence of a least 50 consecutive nucleotides, which is antisense to SEQ ID NO:1 or a sequence having at least 85% identity thereto.
5. A nucleic acid vector comprising the nucleic acid molecule of any one of claims 1 to 4.
6. A host cell comprising the vector of claim 5.
7. An isolated polypeptide having:
  - (a) an amino acid sequence as set forth in SEQ ID No. 2;
  - (b) an amino acid sequence with at least 85% identity to the sequence of (a); or

(c) a subsequence of at least 30 consecutive amino acids of the sequence of (a) or (b), with the proviso that said subsequence does not fall within amino acid nos.1102 and 1152 of SEQ ID NO:2.

5

8. The polypeptide of claim 7, wherein said amino acid sequence in (b) comprises a conservative substitution of at least one amino acid in said amino acid sequence of SEQ ID: NO: 2.

10

9. The polypeptide of claim 7 or 8, wherein said polypeptide has stem cell differentiation inducing activity.

10. The polypeptide of claim 7, said polypeptide having the amino acid sequence shown in SEQ ID NO: 2.

15

11. An antibody that specifically recognizes tenascin W having the amino acid sequence shown in SEQ ID NO: 2 or SEQ ID NO: 4.

20

12. An antibody that specifically recognizes tenascin W for use as a pharmaceutical.

13. The antibody of claim 12, wherein said antibody specifically recognizes tenascin W having the amino acid sequence shown in SEQ ID NO: 2 or SEQ ID NO: 4, for use as a pharmaceutical.

25

14. The use of an antibody that specifically recognizes tenascin W for the manufacture of a medicament, for the prophylaxis or treatment of cancer.

30

15. The use as claimed in claim 14, wherein said cancer is metastatic.

16. The use as claimed in claim 14 or 15, wherein the cancer is a solid tumour.

17. The use as claimed in any of claims 14 to 16, wherein the cancer is a glioblastoma, prostate, lung, colorectal, osteo- or breast carcinoma.

5        18. The use of an antibody that specifically recognizes tenascin W for the prophylaxis or treatment of a bone disease resulting from excessive bone growth.

19. A composition comprising an isolated nucleic acid molecule having a nucleotide sequence selected from the group consisting of:

10        (a)      a nucleotide sequence as set forth in SEQ ID No. 1 or SEQ ID No. 3;  
              (b)      a nucleotide sequence encoding the amino acid sequence shown in SEQ ID NO: 2 or SEQ ID NO: 4;  
              (c)      a nucleotide sequence with at least 35% identity to any one of the sequences of (a) or (b);  
              (d)      a subsequence of at least 15 consecutive nucleotides of the sequence of (a), (b) or (c); and  
              (e)      a nucleotide sequence complementary to (a), (b), (c), or (d),

20        and a pharmaceutically acceptable excipient, diluent or carrier.

20. The composition of claim 19 wherein said nucleic acid molecule has a subsequence that is antisense to SEQ ID NO:1 or SEQ ID NO:3.

25        21. The composition of claim 19, said composition comprising said isolated nucleic acid molecule encoding the amino acid sequence shown in SEQ ID NO: 2 or SEQ ID NO:4.

30        22. A composition as claimed in any one of claims 19 to 21 for use as a pharmaceutical.

23. The use of the compositions of any of claims 19 to 21 for the manufacture of a medicament for the prophylaxis or treatment of cancer.

24. The use of the compositions of any of claims 19 to 21 for the manufacture of a medicament for the prophylaxis or treatment of bone pathologies.

5

25. A composition comprising tenascin-W and a pharmaceutically acceptable excipient, diluent or carrier.

26. The composition of claim 25, wherein said tenascin-W is recombinant.

10

27. A composition as claimed in claim 25, wherein said tenascin-W is a polypeptide having:

(a) an amino acid sequence as set forth in SEQ ID No. 2 or 4;

15

(b) an amino acid sequence with at least 35% identity to the sequence of (a); or  
a subsequence of at least 30 consecutive amino acids of the sequence of (a) or (b).

20

28. The composition of claim 27, said composition comprising said polypeptide encoding the amino acid sequence shown in SEQ ID NO: 4.

25

29. A composition as claimed in any one of claims 25 to 28 for use as a pharmaceutical.

30

30. The use of the compositions of any one of claims 25 to 28 for the manufacture of a medicament for the treatment or prophylactic treatment of any disease or condition requiring increased tenascin-W levels, e.g. thrombosis, wound healing or atherosclerosis, or for the treatment or prophylactic treatment of a condition ameliorated by the promotion of osteogenesis, e.g. bone healing, osteoporosis.

31. A method for treatment or prophylactic treatment of a disease or condition requiring increased tenascin-W levels, e.g. thrombosis, wound healing, atherosclerosis, bone healing and osteoporosis, said method comprising administering an effective amount of the compositions of any one of claims 25 to 28 to an individual in need of such treatment.

5

32. A method of inducing stem cell differentiation into bone cells, said method comprising contacting a suitable stem cell with an effective amount of the composition of any one of claims 25 to 28.

10

33. The method of claim 32, wherein said stem cell is a mesenchymal stem cell.

15 34. The use of tenascin-W as a stem cell marker.

35. A method for identifying modulators of tenascin W function, said method comprising contacting a test compound with a tenascin-W expressing cell and then measuring a change in one or more of:

20 (a) cell proliferation, e.g. cell progression entering S-phase of the cell cycle;

(b) DNA synthesis;

(c) cell adhesion;

(d) cell spreading;

25 (e) focal adhesion and actin stress fibre formation on fibronectin; or

(f) cell binding to extracellular matrix (ECM)

relative to when said test compound is absent.

30 36. A method as claimed in claim 35, further comprising measuring a change in tenascin-W expression in the absence and presence of said test compound.

37. A method as claimed in claim 35 or 36, wherein said cell is a human cell.

38. A method as claimed in any of claims 35 to 37, wherein said cell is present in a tissue sample.

39. A method as claimed in any of claims 35 to 37, wherein said cell is present in a blood sample.

10 40. A method for identifying modulators of tenascin W function, said method comprising:

- (a) contacting a test compound with tenascin W and/or alpha8 beta1 integrin, and
- (b) measuring the binding of said test compound to tenascin-W and/or alpha8 beta1 integrin, or
- (c) measuring a disruption of binding of tenascin-W to alpha8 beta1 integrin,

relative to when said test compound is absent.

20 41. A method as claimed in claim 40, further comprising measuring the binding of a control compound to tenascin-W.

42. A method as claimed in claim 40 or 41, wherein said tenascin-W is attached to a solid surface.

25 43. A method as claimed in any one of claims 41 to 42, wherein said binding is detected using an antibody labelled with a fluorescent label, a fluorescence quencher, a radioactive label, a scintillant or an enzyme.

30 44. A method as claimed in any one of claims 41 to 43, wherein a decrease in binding of tenascin-W to alpha8 beta1 integrin is indicative of an inhibitor of tenascin W function.

45. A substance for the prevention or the prophylactic treatment of a disease or condition dependent on tenascin-W, identified by a method as claimed in any of claims 40 to 44.

5        46. A method of diagnosing or prognosing cancer comprising:

- (a)      analysing a sample obtained from an individual for the presence of tenascin-W protein or transcript
- (b)      correlating the presence of tenascin-W with an unfavourable prognosis or diagnosis.

10

47. A method of diagnosing or prognosing cancer as claimed in claim 46, comprising correlating in (b) an elevated level of tenascin-W protein or transcript relative to healthy tissue with an unfavourable prognosis or diagnosis.

15

48. A method of diagnosing or prognosing cancer as claimed in any of claims 46 to 47, wherein said sample is blood serum or plasma from an individual.

20

49. A method of diagnosing or prognosing cancer as claimed in any of claims 46 to 48, further comprising analysing said sample for the presence of alpha 8 integrin expression, the presence of said alpha 8 integrin correlating with an unfavourable prognosis or diagnosis.

25

50. A method of diagnosing or prognosing cancer as claimed in any of claims 46 to 49, further comprising propagating cells in said sample in cell culture.

30

51. A method of diagnosing or prognosing cancer as claimed in any of claims 48 to 50, wherein said tenascin-W protein is detected using an antibody specific for tenascin-W.

**52. A method of diagnosing or prognosing cancer as claimed in any of claims 48 to 50, wherein said tenascin-W transcripts are detected using a polymerase chain reaction.**

## SEQUENCE LISTING

<110> Novartis Forschungsstiftung, Zweigniederlassung Friedrich Miescher Institute for Biomedical Research

<120> Tenascin-W Compositions and Uses thereof

<130> 1-32411/P1/FMI

<160> 16

<170> PatentIn version 3.1

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1 5 10 15

48

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Ser Val Leu Leu Val Ala Ser Ala Pro Ala Thr Pro Glu Ser Pro Gly  
20 25 30

96

tgc agc aac aaa gag caa cag gtc act gtt agc cac acc tac aag att  
Cys Ser Asn Lys Glu Gln Gln Val Thr Val Ser His Thr Tyr Lys Ile  
35 40 45

144

gac gtg ccc aag tct gct ctg gtt caa gta gag acc cca cag tca  
Asp Val Pro Lys Ser Ala Leu Val Gln Val Glu Thr Asp Pro Gln Ser  
50 55 60

192

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65 70 75 80

240

gag cag aac att atc ttc agg cac aac atc cgt ctt cag aca ccg cag  
Glu Gln Asn Ile Ile Phe Arg His Asn Ile Arg Leu Gln Thr Pro Gln

288

85

90

95

aag aat tgc gac ctg gca gac agt gtc cag gac ctg cta gcc cg <sup>g</sup> atg Lys Asn Cys Asp Leu Ala Asp Ser Val Gln Asp Leu Leu Ala Arg Met	100	105	110	336
aaa aag ctg gag gaa gag atg gca gag ctg aag gag cag tgc aat acc Lys Lys Leu Glu Glu Met Ala Glu Leu Lys Glu Gln Cys Asn Thr	115	120	125	384
aac cgc tgc tgc cag ggg gct gat ctg agc cgt cac tgc agt ggc Asn Arg Cys Cys Gln Gly Ala Ala Asp Leu Ser Arg His Cys Ser Gly	130	135	140	432
cac ggg acc ttc ctc cct gag acc tgc agc tgc cac tgt gac cag ggc His Gly Thr Phe Leu Pro Glu Thr Cys Ser Cys His Cys Asp Gln Gly	145	150	155	480
tgg gag ggc gca gac tgt gat cag ccc acc tgt cct ggg gct tgc aac Trp Glu Gly Ala Asp Cys Asp Gln Pro Thr Cys Pro Gly Ala Cys Asn	165	170	175	528
ggc cac ggg cgc tgt gtg gat ggg cag tgc gtg tgt gac ccc tac Gly His Gly Arg Cys Val Asp Gly Gln Cys Val Cys Asp Ala	180	185	190	576
gtg ggg gtc gac tgc gcc tac gcc gcc tgt ccc cag gac tgc agt ggg Val Gly Val Asp Cys Ala Tyr Ala Ala Cys Pro Gln Asp Cys Ser Gly	195	200	205	624
cat ggc gtg tgc gtg cag ggt gtc tgc cag tgc cac gag gac ttc aca His Gly Val Cys Val Gln Gly Val Cys Gln Cys His Glu Asp Phe Thr	210	215	220	672
gca gag gac tgc agc gag cag cgc tgt cct ggc gac tgt agt ggc aat Ala Glu Asp Cys Ser Glu Gln Arg Cys Pro Gly Asp Cys Ser Gly Asn	225	230	235	720
ggt ttc tgt gac act ggc gag tgt tac tgt gag atg ggc ttt act ggc Gly Phe Cys Asp Thr Gly Glu Cys Tyr Cys Glu Met Gly Phe Thr Gly	245	250	255	768
ccc gac tgt tcc cag gtg gtg gct cct cag ggc ctg cag ttg ctc aag Pro Asp Cys Ser Gln Val Val Ala Pro Gln Gly Leu Gln Leu Leu Lys	260	265	270	816

agc acg gag aac tct ctg ctg gtg agt tgg gag ccc tcc agt gag gta Ser Thr Glu Asn Ser Leu Leu Val Ser Trp Glu Pro Ser Ser Glu Val	864
275                   280                   285	
gac tac tac ctg ctc agc tac tac ccc ctg ggg aag gag caa gct aca Asp Tyr Tyr Leu Leu Ser Tyr Tyr Pro Leu Gly Lys Glu Gln Ala Thr	912
290                   295                   300	
aaa cag gtc cg <sup>g</sup> gta ccc aag gag cag cac acc tat gac atc acc ggc Lys Gln Val Arg Val Pro Lys Glu Gln His Thr Tyr Asp Ile Thr Gly	960
305                   310                   315                   320	
ttg ctg cct gga acc aag tac ata gtc acc ctg cgc aac gtg aag aaa Leu Leu Pro Gly Thr Lys Tyr Ile Val Thr Leu Arg Asn Val Lys Lys	1008
325                   330                   335	
gac att tcc agc agc cct cag cat cta ctt gcc acc aca gac ctt gct Asp Ile Ser Ser Ser Pro Gln His Leu Leu Ala Thr Thr Asp Leu Ala	1056
340                   345                   350	
gtg ctt ggc act gcc tgg gta aat gaa att act gag aca tcc ctc gat Val Leu Gly Thr Ala Trp Val Asn Glu Glu Thr Glu Thr Ser Leu Asp	1104
355                   360                   365	
gtg gag tgg gag aac cct ctg act gag ggt gac tat tac aag ctt cg <sup>g</sup> val Glu Trp Glu Asn Pro Leu Thr Glu Val Asp Tyr Tyr Lys Leu Arg	1152
370                   375                   380	
tat ggc ccc tta aca ggg cag gag gtg aca gag gtc act gtg ccc aag Tyr Gly Pro Leu Thr Gly Gln Glu Val Thr Glu Val Thr Val Pro Lys	1200
385                   390                   395                   400	
agc cgt gat ccc aag agc aga tat gac atc act ggt ctg cag cct gga Ser Arg Asp Pro Lys Ser Arg Tyr Asp Ile Thr Gly Leu Gln Pro Gly	1248
405                   410                   415	
acg gaa tat aaa atc aca gtt gtg ccc atc cga ggt gat ctg gag gga Thr Glu Tyr Lys Ile Thr Val Val Pro Ile Arg Gly Asp Leu Glu Gly	1296
420                   425                   430	
aag ccg att ctc ctg aat ggc agg aca gaa att gat gga cca acc aat Lys Pro Ile Leu Leu Asn Gly Arg Thr Glu Ile Asp Gly Pro Thr Asn	1344
435                   440                   445	
gtg gtc aca aat cag gtg aca gaa gac aca gca tct gtt tcc tgg gat Val Val Thr Asn Gln Val Thr Glu Asp Thr Ala Ser Val Ser Trp Asp	1392

450	455	460	
cca gtg agg gct gac ata gac aag tat gtg gtg cgc tat atc gcc ccc Pro Val Arg Ala Asp Ile Asp Lys Tyr Val Val Arg Tyr Ile Ala Pro			1440
465	470	475	480
gat ggg gag acc aag gag aag gca gta cca aag gac cag agc agc acc Asp Gly Glu Thr Lys Glu Lys Ala Val Pro Lys Asp Gln Ser Ser Thr			1488
485	490		495
gtt ctc aca ggc ctg aag cca gga gag gcc tac aaa gtc ttt gtg tgg val Leu Thr Gly Leu Lys Pro Gly Glu Ala Tyr Lys Val Phe Val Trp			1536
500	505		510
gct gag agg ggc aac caa ggc agc aag aaa gca gac acc aag gcc ctc Ala Glu Arg Gly Asn Gln Gly Ser Lys Lys Ala Asp Thr Lys Ala Leu			1584
515	520		525
aca gaa att gac agt cca gaa aac ctg gtg act gac cgg gtg aca gag Thr Glu Ile Asp Ser Pro Glu Asn Leu Val Thr Asp Arg Val Thr Glu			1632
530	535		540
aac agc ccc tat gtc tcc tgg gac cca gtg gag gct gac atc gac agg Asn Ser Leu Asp Val Val Trp Asp Pro Val Glu Ala Asp Ile Asp Arg			1680
545	550		555
560			
tat gtg gta agc tac act tcc gtg gat gga gag acg aag cag gtt cca Tyr Val Val Ser Tyr Thr Ser Val Asp Gly Glu Thr Lys Gln Val Pro			1728
565	570		575
gtg aag aag gac cag agg agc acc gtc ctc acc ggc ctg agt ccc ggt Val Lys Lys Asp Gln Arg Ser Thr Val Leu Thr Gly Leu Ser Pro Gly			1776
580	585		590
gtg gag tac aaa gtt tac gtg tgg gca gag aaa ggc gat cgg gag agc Val Glu Tyr Lys Val Tyr Val Trp Ala Glu Lys Gly Asp Arg Glu Ser			1824
595	600		605
aag aag gcc aac acc aag gct ccc aca gac atc gac agc ccc aaa aac Lys Lys Ala Asn Thr Lys Ala Pro Thr Asp Ile Asp Ser Pro Lys Asn			1872
610	615		620
ttg gta act gac cag gtg aca gag aac act ctc agt gtc tcc tgg gac Leu Val Thr Asp Gln Val Thr Glu Asn Thr Leu Ser Val Ser Trp Asp			1920
625	630		635
			640

cct gtt cag gcc aac att gac agg tat atg gtg agc tac acc tct gcc Pro Val Gln Ala Asn Ile Asp Arg Tyr Met Val Ser Tyr Thr Ser Ala	645	650	655	1968	
gat gga gag aca aga gag gtc cca gtg cct aag gag aag agc agt acc Asp Gly Glu Thr Arg Glu Val Pro Val Pro Lys Glu Lys Ser Ser Thr	660	665	670	2016	
gtc ctg act ggc ctg agg cca ggt gtg gag tac aag gtc cat gtg tgg val Leu Thr Gly Leu Arg Pro Gly Val Glu Tyr Lys Val His Val Trp	675	680	685	2064	
gcc cag aag ggg acc cag gag agc aga aag gcc aac acc aag gcc ccc Ala Gln Lys Gly Thr Gln Glu Ser Arg Lys Ala Asn Thr Lys Ala Pro	690	695	700	2112	
aca gat att gat ggc ccc aaa aac ctg gtg act gac cag gtg acc gag Thr Asp Ile Asp Gly Pro Lys Asn Leu Val Thr Asp Gln Val Thr Glu	705	710	715	720	2160
acc act ctt agt gtc tcc tgg gac cca gtg gag gct gac att gat agg Thr Leu Ser Val Ser Trp Asp Pro Val Glu Ala Asp Ile Asp Arg	725	730	735		2208
tac atg gtt cgc tac acg tct cct gat gga gag acc aag gag gtg cct Tyr Met Val Arg Tyr Thr Ser Pro Asp Gly Glu Thr Lys Glu Val Pro	740	745	750		2256
gtg tca aag gat aag agc agc aca gtc ctg agg ggc ctg agg cca ggt Val Ser Lys Asp Lys Ser Ser Thr Val Leu Arg Gly Leu Arg Pro Gly	755	760	765		2304
gtg gag tac aag gtg gat gta tgg gcc cag aag ggg gcc cag gac agc Val Glu Tyr Lys Val Asp Val Trp Ala Gln Lys Gly Ala Gln Asp Ser	770	775	780		2352
cgg aag gcc aac acc aag gcc ccc aca gat att gac agc cct aaa aac Arg Lys Ala Asn Thr Lys Ala Pro Thr Asp Ile Asp Ser Pro Lys Asn	785	790	795	800	2400
cta gtg act gag cag gtc gca gag agc act gcc acc gtg tcc tgg gac Leu Val Thr Glu Gln Val Ala Glu Ser Thr Ala Thr Val Ser Trp Asp	805	810	815		2448
cca gta gag gct gac atc gac agg tat gtg gtg cgc tac acc tct gct Pro Val Glu Ala Asp Ile Asp Arg Tyr Val Val Arg Tyr Thr Ser Ala					2496

820

825

830

gat gga gag acc agg gag att cca gtg agg aag gag aag agc agc act      2544  
 Asp Gly Glu Thr Arg Glu Ile Pro Val Arg Lys Glu Lys Ser Ser Thr  
 835                        840                        845

gtc ctc aca ggc ctg aga ccg ggt gtg gag tac acg gtc caa gtg tgg      2592  
 Val Leu Thr Gly Leu Arg Pro Gly Val Glu Tyr Thr Val Gln Val Trp  
 850                        855                        860

gct cag aag ggg gcc cg<sup>g</sup> gag agc aag aag gcc aaa acc aag gcc ccc      2640  
 Ala Gln Lys Gly Ala Arg Glu Ser Lys Lys Ala Lys Thr Lys Ala Pro  
 865                        870                        875                        880

aca gaa att gac agc ccc aag aac ttg gtg acc aac cga gtg aca gaa      2688  
 Thr Glu Ile Asp Ser Pro Lys Asn Leu Val Thr Asn Arg Val Thr Glu  
 885                        890                        895

aat aca gcc acc atc tcc tgg gac cca gtg cga gcc aac att gac agg      2736  
 Asn Thr Ala Thr Ile Ser Trp Asp Pro Val Arg Ala Asn Ile Asp Arg  
 900                        905                        910

tac atg gtt cgc tac acc tct gc<sup>g</sup> gat gga gag act aag gag      2784  
 Tyr Met Val Arg Tyr Thr Ser Ala Asp Gly Glu Thr Lys Glu C<sup>ta</sup>  
 915                        920                        925

gtg tca aag gat cag agt aac acc atc ctg aca ggc ctg aaa cca ggc      2832  
 Val Ser Lys Asp Gln Ser Asn Thr Ile Leu Thr Gly Leu Lys Pro Gly  
 930                        935                        940

atg gaa tat acc att cat gtg tgg gcc cag aag ggg gcc cg<sup>g</sup> gag agc      2880  
 Met Glu Tyr Thr Ile His Val Trp Ala Gln Lys Gly Ala Arg Glu Ser  
 945                        950                        955                        960

aag aag gct gat acc aag gcc cta aca gaa att gac cct ccc aga aat      2928  
 Lys Lys Ala Asp Thr Lys Ala Leu Thr Glu Ile Asp Pro Pro Arg Asn  
 965                        970                        975

ctc cgt ccg ttc ggg gta aca cat tct ggt ggg gtt ttg acc tgg ttg      2976  
 Leu Arg Pro Phe Gly Val Thr His Ser Gly Gly Val Leu Thr Trp Leu  
 980                        985                        990

ccc cca tct gct caa att gat ggc tac att ttg acc tac cag ttc cca      3024  
 Pro Pro Ser Ala Gln Ile Asp Gly Tyr Ile Leu Thr Tyr Gln Phe Pro  
 995                        1000                        1005

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Asn Gly Thr Val Lys Gly Val Glu Leu Pro Arg Gly Gln Gln Arg		
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Phe Glu Leu Gln Asp Leu Glu Gln Gly Val Thr Tyr Pro Val Ser		
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Leu Val Ala Phe Lys Gly Asn Gln Arg Ser Arg Thr Val Ser Thr		
1040 1045 1050		
acc ctt tct aca gtg gat gct cgc ttt cca cac ccc tca gac tgc		3204
Thr Leu Ser Thr Val Asp Ala Arg Phe Pro His Pro Ser Asp Cys		
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agt caa gtt cag cag aac acc aac gct gcc agt ggg ctc tac acc		3249
Ser Gln Val Gln Gln Asn Thr Asn Ala Ala Ser Gly Leu Tyr Thr		
1070 1075 1080		
atc tac ctc aat ggt gat gcc agc cgg atc gag cag gtg tac tgc		3294
Ile Tyr Leu Asn Gly Asp Ala Ser Arg Pro Met Gln Val Tyr Cys		
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gac atg gac act gac gga ggc ggc tgg atc gtc ttc cag aga cgg		3339
Asp Met Asp Thr Asp Gly Gly Gly Trp Ile Val Phe Gln Arg Arg		
1100 1105 1110		
aac act ggg cag ctg gat ttc ttc aag cgt tgg cgg agt tat gta		3384
Asn Thr Gly Gln Leu Asp Phe Phe Lys Arg Trp Arg Ser Tyr Val		
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Glu Gly Phe Gly Asp Pro Met Lys Glu Phe Trp Leu Gly Leu Asp		
1130 1135 1140		
aaa cta cat aat ctc acc act ggc acc acc act cgg tat gag gtg		3474
Lys Leu His Asn Leu Thr Thr Gly Thr Thr Arg Tyr Glu Val		
1145 1150 1155		
agg gca gac tta cag act ttc aat gaa tct gcc tac gct gta tat		3519
Arg Ala Asp Leu Gln Thr Phe Asn Glu Ser Ala Tyr Ala Val Tyr		
1160 1165 1170		
gat ttc ttc caa gtg gca tcc agc aaa gag cgg tac aag ctg tcg		3564
Asp Phe Phe Gln Val Ala Ser Ser Lys Glu Arg Tyr Lys Leu Ser		

1175	1180	1185	
gtt ggg aaa tac aga ggc aca	gcc ggg gat gct ctc	acc tac cac	3609
val Gly Lys Tyr Arg Gly Thr	Ala Gly Asp Ala Leu	Thr Tyr His	
1190	1195	1200	
aat gga tgg aag ttc acg act	ttt gac aga gac agt	gat att gcc	3654
Asn Gly Trp Lys Phe Thr Thr	Phe Asp Arg Asp Ser	Asp Ile Ala	
1205	1210	1215	
ctc agc aac tgt gca ctg acg	cat cat ggt ggc tgg	tgg tat aag	3699
Leu Ser Asn Cys Ala Leu Thr	His His Gly Gly Trp	Trp Tyr Lys	
1220	1225	1230	
aac tgc cat ttg gcc aac ccg	aat ggc aaa tat ggg	gag acc aag	3744
Asn Cys His Leu Ala Asn Pro	Asn Gly Lys Tyr Gly	Glu Thr Lys	
1235	1240	1245	
cac agc gag ggg gtg aac tgg	gag cca tgg aag gga	cat gag ttc	3789
His Ser Glu Gly Val Asn Trp	Glu Pro Trp Lys Gly	His Glu Phe	
1250	1255	1260	
tcc att ccc tat gtg gag ccg	aaa atc cgc ccg ttt	ggt tac agc	3834
Ser Ile Pro Tyr Leu Lys Ile Arg Pro Phe	Gly Tyr Ser		
1265	1270	1275	
aga gac cgt ttc tct ggc aga	aag aag cgc tcc ata	gga aaa gca	3879
Arg Asp Arg Phe Ser Gly Arg	Lys Lys Arg Ser Ile	Gly Lys Ala	
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Arg Met Phe			
1295			

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<212> PRT  
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Ser Val Leu Leu Val Ala Ser Ala Pro Ala Thr Pro Glu Ser Pro Gly

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25

30

Cys Ser Asn Lys Glu Gln Gln Val Thr Val Ser His Thr Tyr Lys Ile  
35 40 45

Asp Val Pro Lys Ser Ala Leu Val Gln Val Glu Thr Asp Pro Gln Ser  
50 55 60

Leu Ser Asp Asp Gly Thr Ser Leu Leu Ala Pro Gly Glu Asp Gly Glu  
65 70 75 80

Glu Gln Asn Ile Ile Phe Arg His Asn Ile Arg Leu Gln Thr Pro Gln  
85 90 95

Lys Asn Cys Asp Leu Ala Asp Ser Val Gln Asp Leu Leu Ala Arg Met  
100 105 110

Lys Lys Leu Glu Glu Glu Met Ala Glu Leu Lys Glu Gln Cys Asn Thr  
115 120 125

Arg Cys Cys Gln Gly Ala Ala Asp Leu Ser Arg His Cys Ser Gly  
130 135 140

Gly Thr Phe Leu Pro Glu Thr Cys Ser Cys His Cys Asp Gln Gly  
145 150 155 160

Trp Glu Gly Ala Asp Cys Asp Gln Pro Thr Cys Pro Gly Ala Cys Asn  
165 170 175

Gly His Gly Arg Cys Val Asp Gly Gln Cys Val Cys Asp Ala Pro Tyr  
180 185 190

Val Gly Val Asp Cys Ala Tyr Ala Ala Cys Pro Gln Asp Cys Ser Gly  
195 200 205

His Gly Val Cys Val Gln Gly Val Cys Gln Cys His Glu Asp Phe Thr  
210 215 220

Ala Glu Asp Cys Ser Glu Gln Arg Cys Pro Gly Asp Cys Ser Gly Asn  
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Gly Phe Cys Asp Thr Gly Glu Cys Tyr Cys Glu Met Gly Phe Thr Gly  
245 250 255

Pro Asp Cys Ser Gln Val Val Ala Pro Gln Gly Leu Gln Leu Lys  
260 265 270

Ser Thr Glu Asn Ser Leu Leu Val Ser Trp Glu Pro Ser Ser Glu Val  
275 280 285

Asp Tyr Tyr Leu Leu Ser Tyr Tyr Pro Leu Gly Lys Glu Gln Ala Thr  
290 295 300

Lys Gln Val Arg Val Pro Lys Glu Gln His Thr Tyr Asp Ile Thr Gly  
305 310 315 320

Leu Leu Pro Gly Thr Lys Tyr Ile Val Thr Leu Arg Asn Val Lys Lys  
325 330 335

Asp Ile Ser Ser Ser Pro Gln His Leu Leu Ala Thr Thr Asp Leu Ala  
340 345 350

Val Leu Gly Thr Ala Trp Val Asn Glu Glu Thr Glu Thr Ser Leu Asp  
355 360 365

Val Glu Trp Glu Asn Pro Leu Thr Glu Val Asp Tyr Tyr Lys Leu Arg  
370 375 380

Tyr Gly Pro Leu Thr Gly Gln Glu Val Thr Glu Val Thr Val Pro  
385 390 395

Ser Arg Asp Pro Lys Ser Arg Tyr Asp Ile Thr Gly Leu Gln Pro Gly  
405 410 415

Thr Glu Tyr Lys Ile Thr Val Val Pro Ile Arg Gly Asp Leu Glu Gly  
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Lys Pro Ile Leu Leu Asn Gly Arg Thr Glu Ile Asp Gly Pro Thr Asn  
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Val Val Thr Asn Gln Val Thr Glu Asp Thr Ala Ser Val Ser Trp Asp  
450 455 460

Pro Val Arg Ala Asp Ile Asp Lys Tyr Val Val Arg Tyr Ile Ala Pro  
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Asp Gly Glu Thr Lys Glu Lys Ala Val Pro Lys Asp Gln Ser Ser Thr  
485 490 495

Val Leu Thr Gly Leu Lys Pro Gly Glu Ala Tyr Lys Val Phe Val Trp  
500 505 510

Ala Glu Arg Gly Asn Gln Gly Ser Lys Lys Ala Asp Thr Lys Ala Leu  
515 520 525

Thr Glu Ile Asp Ser Pro Glu Asn Leu Val Thr Asp Arg Val Thr Glu  
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Asn Ser Leu Ser Val Ser Trp Asp Pro Val Glu Ala Asp Ile Asp Arg  
545 550 555 560

Tyr Val Val Ser Tyr Thr Ser Val Asp Gly Glu Thr Lys Gln Val Pro  
565 570 575

Val Lys Asp Gln Arg Ser Thr Val Leu Thr Gly Leu Ser Pro Gly  
580 585 590

Val Glu Tyr Lys Val Tyr Val Trp Ala Glu Lys Gly Asp Arg Glu Ser  
595 600 605

Lys Lys Ala Asn Thr Lys Ala Pro Thr Asp Ile Asp Ser Pro Lys Asn  
610 615 620

Leu Val Thr Asp Gln Val Thr Glu Asn Thr Lys Ser Val Asp Trp Asp  
625 630 635 640

Pro Val Gln Ala Asn Ile Asp Arg Tyr Met Val Ser Tyr Thr Ser Ala  
645 650 655

Asp Gly Glu Thr Arg Glu Val Pro Val Pro Lys Glu Lys Ser Ser Thr  
660 665 670

Val Leu Thr Gly Leu Arg Pro Gly Val Glu Tyr Lys Val His Val Trp  
675 680 685

Ala Gln Lys Gly Thr Gln Glu Ser Arg Lys Ala Asn Thr Lys Ala Pro  
690 695 700

Thr Asp Ile Asp Gly Pro Lys Asn Leu Val Thr Asp Gln Val Thr Glu  
705 710 715 720

Thr Thr Leu Ser Val Ser Trp Asp Pro Val Glu Ala Asp Ile Asp Arg  
725 730 735

Tyr Met Val Arg Tyr Thr Ser Pro Asp Gly Glu Thr Lys Glu Val Pro  
740 745 750

val Ser Lys Asp Lys Ser Ser Thr Val Leu Arg Gly Leu Arg Pro Gly  
755 760 765

val Glu Tyr Lys Val Asp Val Trp Ala Gln Lys Gly Ala Gln Asp Ser  
770 775 780

Arg Lys Ala Asn Thr Lys Ala Pro Thr Asp Ile Asp Ser Pro Lys Asn  
785 790 795 800

Leu Val Thr Glu Gln Val Ala Glu Ser Thr Ala Thr Val Ser Trp Asp  
805 810 815

Pro Val Glu Ala Asp Ile Asp Arg Tyr Val Val Arg Tyr Thr Ser Ala  
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Asp Gly Glu Thr Arg Glu Ile Pro Val Arg Lys Glu Lys Ser Ser Thr  
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val Leu Thr Gly Leu Arg Pro Gly Val Glu Tyr Thr Val Gln Val Trp  
850 855 860

Ala Gln Lys Gly Arg Glu Val Lys Lys Ala Lys Thr Lys Ala Pro  
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Thr Glu Ile Asp Ser Asn Leu Val Thr Asn Arg Val Thr Glu  
885 890 895

Asn Thr Ala Thr Ile Ser Trp Asp Pro Val Arg Ala Asn Ile Asp Arg  
900 905 910

Tyr Met Val Arg Tyr Thr Ser Ala Asp Gly Glu Thr Lys Glu Ile Pro  
915 920 925

val Ser Lys Asp Gln Ser Asn Thr Ile Leu Thr Gly Leu Lys Pro Gly  
930 935 940

Met Glu Tyr Thr Ile His Val Trp Ala Gln Lys Gly Ala Arg Glu Ser  
945 950 955 960

Lys Lys Ala Asp Thr Lys Ala Leu Thr Glu Ile Asp Pro Pro Arg Asn  
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Leu Arg Pro Phe Gly Val Thr His Ser Gly Gly Val Leu Thr Trp Leu  
980 985 990

Pro Pro Ser Ala Gln Ile Asp Gly Tyr Ile Leu Thr Tyr Gln Phe Pro  
995 1000 1005

Asn Gly Thr Val Lys Gly Val Glu Leu Pro Arg Gly Gln Gln Arg  
1010 1015 1020

Phe Glu Leu Gln Asp Leu Glu Gln Gly Val Thr Tyr Pro Val Ser  
1025 1030 1035

Leu Val Ala Phe Lys Gly Asn Gln Arg Ser Arg Thr Val Ser Thr  
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Thr Leu Ser Thr Val Asp Ala Arg Phe Pro His Pro Ser Asp Cys  
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Ser Gln Val Gln Gln Asn Thr Asn Ala Ala Ser Gly Leu Tyr Thr  
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Ile Tyr Leu Asn Gly Asp Ala Ser Arg Pro Met Gln Val Tyr Cys  
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Arg Met Asp Thr Asp Gly Gly Gly Trp Ile Val Phe Gln Arg Arg  
1100 1105 1110

Asp Thr Gly Gln Leu Asp Phe Phe Lys Arg Trp Arg Ser Tyr Val  
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Glu Gly Phe Gly Asp Pro Met Lys Glu Phe Trp Leu Gly Leu Asp  
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Lys Leu His Asn Leu Thr Thr Gly Thr Thr Thr Arg Tyr Glu Val  
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Arg Ala Asp Leu Gln Thr Phe Asn Glu Ser Ala Tyr Ala Val Tyr  
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Asp Phe Phe Gln Val Ala Ser Ser Lys Glu Arg Tyr Lys Leu Ser  
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Val Gly Lys Tyr Arg Gly Thr Ala Gly Asp Ala Leu Thr Tyr His  
1190 1195 1200

Asn Gly Trp Lys Phe Thr Thr Phe Asp Arg Asp Ser Asp Ile Ala  
1205 1210 1215

Leu Ser Asn Cys Ala Leu Thr His His Gly Gly Trp Trp Tyr Lys

1220

1225

1230

Asn Cys His Leu Ala Asn Pro Asn Gly Lys Tyr Gly Glu Thr Lys  
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His Ser Glu Gly Val Asn Trp Glu Pro Trp Lys Gly His Glu Phe  
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Ser Ile Pro Tyr Val Glu Leu Lys Ile Arg Pro Phe Gly Tyr Ser  
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Arg Met Phe  
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&lt;222&gt; (1)..(3885)

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&lt;309&gt; 1999-04-21

&lt;313&gt; (1)..(3885)

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Ala Ser Ala Pro Ala Thr Leu Glu Pro Pro Gly Cys Ser Asn Lys Glu  
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caa cag gtc act gtc agc cac acc tac aag atc gat gtg ccc aag tct 144  
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gcc ttg gtt cag gtt gac gct gac cct cag ccc ctc agt gac gat ggg Ala Leu Val Gln Val Asp Ala Asp Pro Gln Pro Leu Ser Asp Asp Gly	192
50 55 60	
 gct tcg ctc ttg gcc ctg ggg gag gcc agg gag gaa cag aac atc atc Ala Ser Leu Leu Ala Leu Gly Glu Ala Arg Glu Glu Gln Asn Ile Ile	240
65 70 75 80	
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85 90 95	
 gca ggc agt gtc cag gac ctc ctg gcc cgg gtg aag aag ctg gag gaa Ala Gly Ser Val Gln Asp Leu Leu Ala Arg Val Lys Lys Leu Glu Glu	336
100 105 110	
 gag atg gtg gag atg aag gaa cag tgt agt gcc cag cgc tgc tgc cag Glu Met Val Glu Met Lys Glu Gln Cys Ser Ala Gln Arg Cys Cys Gln	384
115 120 125	
 gga gtc act gat cta agc cgc cac tgc agc ggc cac tgc tgc tcc tcc Gly Val Thr Asp Leu Ser Arg His Cys Ser Gln Asp Gly Tyr Ile Ser	432
130 135 140	
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145 150 155 160	
 tgc gag cgg ctg gcc tgc ccc ggg ggc tgc agc ggc cac ggg cgt tgc Cys Glu Arg Leu Ala Cys Pro Gly Ala Cys Ser Gly His Gly Arg Cys	528
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 gtg gac ggg cgc tgc ctg tgc cat gag ccc tac gtg ggt gcc gac tgc Val Asp Gly Arg Cys Leu Cys His Glu Pro Tyr Val Gly Ala Asp Cys	576
180 185 190	
 ggc tac ccg gcc tgc cct gag aac tgc agc gga cac ggc gag tgc gtg Gly Tyr Pro Ala Cys Pro Glu Asn Cys Ser Gly His Gly Glu Cys Val	624
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agc tac tac ccc ctg ggg aag gag ctc tct ggg aag cag atc caa gtg Ser Tyr Tyr Pro Leu Gly Lys Glu Leu Ser Gly Lys Gln Ile Gln Val				912
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ccc aag gag cag cac agc tat gag att ctt ggt ttg ctg cct gga acc Pro Lys Glu Gln His Ser Tyr Glu Ile Leu Gly Leu Leu Pro Gly Thr				960
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325	330		335	
cca cag cat cta ctt gcc acc aca gac ctt gct gtg ctt ggc act gcc Pro Gln His Leu Leu Ala Thr Thr Asp Leu Ala Val Leu Gly Thr Ala				1056
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485 490 495	
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gcc att gac aag tac gtg gtg cgc tac acc tct gct ggt gga gag acc Ala Ile Asp Lys Tyr Val Val Arg Tyr Thr Ser Ala Gly Gly Glu Thr				1968
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gcc acc att gac agg tat gtg gtg cac tac acg tct gcc aac gga gag Ala Thr Ile Asp Arg Tyr Val Val His Tyr Thr Ser Ala Asn Gly Glu 820	825		830	2496
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cgc tac acc tct gct gac gga gag acc agg gag gtt ccg gtg ggg aag Arg Tyr Thr Ser Ala Asp Gly Glu Thr Arg Glu Val Pro Val Gly Lys 915	920	925		2784
gag cac agc agc act gtc ctg acg ggc ctg aga cca ggc atg gag tac Glu His Ser Ser Thr Val Leu Thr Gly Leu Arg Pro Gly Met Glu Tyr 930	935	940		2832
atg gtg cac gtg tgg gcc cag aag ggg gcc cag gag agc aag aag gct Met Val His Val Trp Ala Gln Lys Gly Ala Gln Glu Ser Lys Lys Ala 945	950	955	960	2880
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970

975

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Tyr Arg Gly Thr Ala Gly Asp	Ala Leu Thr Tyr His	Asn Gly Trp	
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Lys Phe Thr Thr Phe Asp Arg	Asp Asn Asp Ile Ala	Leu Ser Asn	
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Cys His His His Gly Gly Trp Trp Tyr Lys Asn Cys His			
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Tyr Val Glu Leu Lys Ile Arg Pro His Gly Tyr Ser	Arg Glu Pro		
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